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Report No. 27.

TWELFTH
ANNUAL REPORT
OF THE
RESEARCH COUNCIL OF ALBERTA
1931

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The Research Council of Alberta, formerly known as The Scientific and Industrial Research Council of Alberta, was formed in January, 1921. It was incorporated under its new name by an act of the Legislature of the Province of Alberta March 21st, 1930.

The personnel of the Council at the present time is as follows:

J. E. Brownlee, Premier of Alberta, Chairman.
R. G. Reid, Minister of Lands and Mines.
O. L. McPherson, Minister of Public Works.
R. C. Wallace, President, University of Alberta, Director of Research.
R. S. L. Wilson, Dean, Faculty of Applied Science, University of Alberta.
G. A. Vissac, Esq., Blairmore.
J. I. McFarlane, Esq., Calgary.
R. J. Dinning, Esq., Edmonton.
Secretary, A. E. Cameron, University of Alberta.

Technical Advisors (meeting with Council)

Prof. J. A. Allan—Geology.
Prof. N. C. Pitcher—Mining Engineering.
Prof. E. Stansfield—Chemical Engineering.

The Council carries on its work in cooperation with the University of Alberta where its laboratories are situated. Requests for information and reports should be addressed to the Secretary, Research Council of Alberta, University of Alberta, Edmonton, Canada.

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University of Alberta,
Edmonton, Alberta,
February 25th, 1932.

Hon. J. E. Brownlee,
Premier,
Edmonton, Alberta.

Sir:

Under instruction from the Research Council of Alberta, I herewith submit their Twelfth Annual Report. This covers the work done under their direction during the year ending December 31st, 1931.

Respectfully submitted,
Robert C. Wallace,
Director of Research.

TWELFTH ANNUAL REPORT OF THE RESEARCH COUNCIL OF ALBERTA

ORGANIZATION.

In the organization of the Provincial Government the Research Council is attached to the Department of the Executive Council.

The Research Council controls the policies of research and administers the funds voted annually by the Legislature for this purpose. The Council usually meets three or four times a year. The Director of Research, Dr. R. C. Wallace, President of the University of Alberta, is in executive charge of the work and is assisted by a technical advisory committee consisting of the following members:

President R. C. Wallace, Chairman.
Dean R. S. L. Wilson, Vice-Chairman.
J. A. Allan,
N. C. Pitcher,
E. Stansfield,
K. A. Clark,
F. A. Wyatt,
E. H. Boomer,
R. L. Rutherford,
H. J. MacLeod,
A. E. Cameron, Secretary.

The offices and laboratories of the Council are situated in the buildings of the University of Alberta.

STAFF.

The permanent staff of the Council as of December 31st, 1931, was as follows:

Edgar Stansfield, Chief Chemical Engineer;
K. A. Clark, Research Engineer, *Road Materials;*
R. L. Rutherford, Geologist, *Geology;*
W. A. Lang, Engineer, *Fuels;*
D. S. Pasternack, Engineer, *Road Materials;*
K. C. Gilbart, Assistant Engineer, *Fuels;*
R. G. Brewer, Assistant Engineer, *Fuels;*
H. E. Morris, Fuel Analyst;
J. L. Doughty, Research Assistant, *Soils;*
O. R. Younge, Research Assistant, *Soils;*
Joseph Edwards, Research Assistant, *Natural Gas;*
P. E. Gishler, Research Assistant, *Natural Gas;*
Frank J. Hastie, Laboratory Assistant, *Fuels;*
Robert M. Scott, Laboratory Assistant, *Road Materials;*
Hazel M. Wortman, Accountant;
Gladys P. Speer, Geological Stenographer.

In addition to the above, Professors J. A. Allan and N. C. Pitcher, of the University of Alberta, are in permanent charge of the Council's research work in Geology and Mining Engineering respectively. Professor F. A. Wyatt is in charge of the Council's work on Soil Surveying. Dr. E. H. Boomer has carried out natural gas and hydrogenation investigations. Dr. A. E. Cameron acts as secretary to the Council and has charge of the office staff.

FUELS.

The main work of the year was the continuation of a detailed examination of thirteen typical coals occurring in the south of the Province. A start was made on a similar examination of seventeen typical coals occurring further north in the Province from Nordegg to Sheerness. These surveys are being made with the cooperation and assistance of the Dominion Department of Mines, the Provincial Mines Branch, and the National Research Council. They were commenced to ascertain the cost and value of such work; it now seems assured that similar work will be done for other parts of the Dominion. The samples taken for the second survey do not show such a wide range of fixed carbon in pure coal substance as was found in the first, but the second survey will give information, not obtained in the first, as to the comparison of the coals from two seams in the same locality.

Good progress was made during the year on improved methods for the standardised air drying of coal, and a new method was evolved for studying the moisture holding character of coal. It is now possible to determine the true inherent moisture in a coal sample even when this is received covered with surface moisture. Approximately the usual number of coal samples were received during the year; these included coal from 19 mines not previously sampled. Many ultimate analyses were made and special attention was again given to physical tests of the coal. Some progress was made with the study of micro-structure of a few coals.

A satisfactory technique was developed for the extraction of coal with organic solvents at atmospheric and at high pressure, but many unexpected difficulties had first to be overcome. Tests were made with benzene and benzene-alcohol mixtures at high pressures, and with various solvents at ordinary pressures. Tests were also made in oxidising, reducing and other atmospheres.

Attempts were made to briquette coals at high temperature, thus taking advantage of the bituminous binder present in coking coals. Neither of the two presses available were found suitable for this work, and the results obtained did not warrant further effort with the present equipment.

A decision of the United States Treasury, in September, prevented the further duty free exportation of Lethbridge coal to the United States. Successful steps were taken to have this decision reconsidered and, following a second ruling in December, Lethbridge district coal is once more duty free.

The staff and laboratory facilities of the Fuels Division have been used increasingly for investigation outside the main programme. Such investigations during the year included the combustion of charcoal, drying of wheat, study of motor and lubricating oils, fire hazards in buildings, and the corrosion and protection of metals.

A fuller account of all this work is given in the report of the Fuels Division. Particulars are also given of specific gravity of coal curves, and reprints of technical papers published elsewhere, which can be supplied upon request.

GEOLOGY.

The work of the Geological Survey Division of the Council is directed by J. A. Allan in conjunction with the Department of Geology at the University of Alberta. P. S. Warren has again cooperated with the Geology Division in determining palaeontological material collected during the field surveys. In return for this cooperation R. L. Rutherford assists in teaching in the Department of Geology.

During the field season geological conditions and mineral deposits were examined by J. A. Allan and R. L. Rutherford in ten different areas. One field party operated throughout the season and a second party carried on field work for a shorter period.

Much of the field season was spent on an investigation of the occurrence of iron at Burmis, building stone at Cochrane, and gypsum on Mowitch creek at the north end of Jasper Park. In addition to these major surveys shorter periods were spent investigating the coal seams at Meeting creek and Battle river, graphite near the west boundary of Alberta in Tonquin valley, volcanic dust at Calgary, clay on McLeod river, phosphate and gypsum in the Athabaska valley, and structural geology on Pembina river. P. S. Warren obtained additional information on the Willow creek coal and the structure along Athabaska valley between Jasper and Pocahontas. Temporary field assistance of a satisfactory nature was received from G. A. Moody, H. H. Beach, J. Tatham and W. Hole, all students in engineering from the University of Alberta.

J. A. Allan in company with C. H. Freeman of the Mines Branch, Ottawa, obtained information from field observations on moulding sand at various points in Alberta. Assistance and advice was given to Mr. W. Calder, Director of the Petroleum and Natural Gas Division of the Department of Lands and Mines.

The drafting room was in operation throughout the year and P. F. Parsons rendered efficient services. The office of the Geology Division was closed in June, July and August. The efficient services of Mrs. M. Sandin in the office terminated on June 1st, and she resigned. In September, Miss Gladys Speer was appointed as stenographer to the Geology Division and has since rendered satisfactory service. Since the organization of the Research Council, the Geological Survey Division has examined about 36,000 square miles or about 14 per cent of the area of Alberta. This means that there is still much geological information to be obtained from the remaining 220,000 square miles within this Province.

Details of the field work carried out by the Geological Survey Division in 1931 are given in a later part of this report.

ROAD MATERIALS.

The Road Materials Division, during the past year, has followed up the preliminary work discussed in the Annual Report for 1930, on unexpected difficulties encountered at its separation plant. The results have been most gratifying. They have changed the separation process from one founded on the practical but none too satisfactory basis of trial-and-error experience to one which is firmly founded on knowledge of the reasons why the process works. Briefly, bituminous sand will separate in hot water if it is neutral or alkaline in reaction and if it contains no lime. This statement is amplified in an attached report.

SOIL SURVEYS.

At the request of the Provincial Government the Research Council during 1930 undertook the general supervision of extensive soil surveys in the northern portions of the Province. Three field survey parties were in the field for the greater part of the field season. The work was directed for the Council by Dr. F. A. Wyatt, Professor of Soils at the University of Alberta. J. L. Doughty, with H. J. Mather as assistant, examined the area from the Sand river westward to Plamondon and north to the Wandering river settlement. O. R. Younge, with R. Haugen as assistant, examined the area between Cold lake and Cheecham. N. Holowaychuk and A. D. Paul examined the area from Grouard to Peace River.

Preliminary reports covering the results of these field surveys appear in the attached reports of the Soils Survey Division.

CHEMICAL UTILIZATION OF NATURAL GAS.

The studies on the chemical utilization of Alberta natural gas were confined to three principal divisions; the hydrogenation at high temperatures and pressures of McMurray bitumen and of a number of Alberta coals, the reactions of water-gas and carbon-dioxide-hydrogen mixtures at high temperatures and pressures and the pyrolysis of natural gas. The progress in hydrogenation was distinctly encouraging resulting in evidence that McMurray bitumen can be very largely reduced to gasoline and that a variety of Alberta coals can be reduced nearly completely to liquid and gaseous products. The pyrolysis project was carried to a satisfactory degree in the laboratory and operations transferred to a semi-commercial scale plant in Calgary. An examination on a laboratory scale of the pyrolysis of stabilizer gas was initiated and the results show great promise.

The National Research Council of Canada continued its cooperation and defrayed about one-third of the cost of the investigations.

A brief report summarizing the results of these studies appears in the attached report on Natural Gas Research.

MISCELLANEOUS.

E. Stansfield has assisted since 1927 with an investigation on the drying of wheat for the National Research Council, and since 1929 with an investigation for the Provincial Government on motor fuel and lubricating oils in Alberta. Both these investigations were completed and reported during the year.

An investigation of the corrosion of telephone wires was made, at the request of the Department of Railways and Telephones, by a committee consisting of E. Stansfield, A. E. Cameron, H. J. MacLeod, J. W. Shipley and W. A. Lang, acting in cooperation with Messrs. W. C. Bruce and A. M. Allen of the Telephone Branch. Trouble had occasionally been reported, particularly in the joints. Soldered joints, of the type recently adopted by the Department, were found most satisfactory and a hot asphalt coating was found to be the best preservative. The findings of the committee are being utilized by the Department.

E. Stansfield attended the Third International Conference on Institute of Mining and Metallurgy in Ottawa in March. He also visited the coal research laboratories in Ottawa and Pittsburgh and attended committee meetings on coal problems in those cities at that time.

E. Stansfield delivered in October the second lecture of a Symposium on Fuels (Coal) organised by McGill University; he also addressed the Ottawa Branch of the Society of Chemical Industry on "Ten Years Study of Coal by the Research Council of Alberta."

E. Stansfield attended the Third International Conference on Bituminous Coal at Pittsburgh in November.

ACKNOWLEDGMENTS.

Appreciation is expressed to the Dominion Department of Mines and to the Provincial Mines Branch for cooperation and assistance in the coal survey in central Alberta, and to the operators who gave facilities for the sampling.

Appreciation is also expressed to the Principal and members of staff of the Provincial Institute of Technology and Art at Calgary for laboratory accommodation and facilities for natural gas research.

PUBLICATIONS DURING 1931.

News Letter No. 6, January, 1931. Low Temperature Carbonization of Alberta Coal.

Report No. 26. Eleventh Annual Report of the Research Council of Alberta, 1930. 76 pages.

News Letter No. 7, June, 1931. "Review of Recent Literature on Coal," by N. C. Pitcher.

"Report by Committee of Enquiry into Motor Fuel and Lubricating Oils in Alberta," by E. Stansfield and others, Provincial Legislature, Sessional Paper No. 50, 1931.

"The Composition and Classification of Canadian Coals." Lecture by E. Stansfield, McGill University Fuel (Coal) Symposium, October, 1931.

"Important Experiments on Alberta's Tar Sands," K. A. Clark, The Monetary Times, Canadian Achievement Number, January 9th, 1931.

"Separation of Bitumen from Bituminous Sand," K. A. Clark, Nature, February 7th, 1931, p. 199.

"Phosphorus Studies on Alberta Soils," by J. L. Doughty, Scientific Agriculture, September, 1931.

Discussion on "A Structure Section across the Canadian Rockies," by R. L. Rutherford. Jl. Geol., Vol. 39, No. 6, 1931, p. 597.

Discussion on "The Water Supply Problem in Southern Saskatchewan," J. A. Allan, The Engineering Journal, Vol. 14, No. 4, 1931, p. 257.

Discussion on "Structure and Oil Prospects on the Eastern Foothills," J. A. Allan, Engineering Journal, Vol. 14, No. 6, 1931, p. 343.

FUELS DIVISION

BY E. STANSFIELD, W. A. LANG, K. C. GILBART, R. G. BREWER, M. F. TESKEY AND H. E. MORRIS.

All members of the staff assisted with the two coal surveys described later. W. A. Lang gave special attention to the solubility of coals in organic solvents, to hot briquetting of coal and to the corrosion of metals tests. K. C. Gilbart worked on the moisture holding character of coal. He also made stove tests with charcoal. R. G. Brewer worked on the fusion of coal ash and on the hot briquetting of coal. M. F. Teskey, until his resignation, worked on the micro-structure of coal, and the analysis of coal. H. E. Morris later made many ultimate and other analyses of coal.

COALS TESTED.

Provincial Mine Inspectors submitted 25 channel samples of coal for analysis and 9 check samples of coals shipped for coking tests. Coal for investigation was obtained from 17 mines in connection with a special survey; one large and ten small samples being taken from each mine. Coal operators submitted 5 samples of washery refuse. The Fuel Research Laboratories at Ottawa sent six coal samples for comparison of methods. The staff of the Division collected 19 samples of run-of-mine and slack output from local mines. Six miscellaneous samples were also received. Samples were received during the year from 19 mines not previously sampled and coal has now been analysed from over 300 mines.

SAMPLING AND ANALYSIS.

No notable change has been made during the year in the regular methods of sampling and analysis. The storage of samples under water, tried with a few samples the previous year, has been definitely abandoned. Storage under reduced pressure, or in natural gas, is employed when it is essential to avoid oxidation.

The method developed for the determination of the constituents of coal soluble in caustic potash, and the significance of this determination in relation to the maturity of the coal, has been published separately[1] and reprints can be supplied. Improvements have been made in the method employed for the ignition temperature of coal, but this work is not yet completed for publication. Improved methods for the study of moisture in coal are described in the following section.

The Fuel Research Laboratories of the Department of Mines in Ottawa distributed sets of six coal samples to a number of laboratories where coal analyses are made. The samples were analysed in these laboratories by the regular methods employed, and a subsequent report from Ottawa showed very satisfactory agreement between the results obtained in Ottawa and Edmonton.

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[1] Determination of the Alkali Soluble Ulmins in Coal, by E. Stansfield and K. C. Gilbart. Trans. A. I. M. and M. E., Coal Division, 1932.

MOISTURE IN COAL.

Routine air drying of samples is now carried out in a new apparatus in which a neutral atmosphere is maintained at 30°C and 60% humidity. Check determinations of the total moisture in the coal as received are frequently made by distillation with xylene or toluene in a newly constructed apparatus. A method has been developed for determining the variations in vapour pressure of a coal with its moisture content. This method has been adopted to give the true inherent moisture content of a coal sample, even when the sample is received from a wet place in the mine where the regular determination would show too high a value. This air-drying and moisture work has been published separately[2] and reprints can be supplied.

NEW APPARATUS.

A high pressure autoclave, of 7 litres capacity, with electric heating was purchased for work on the solubility of coal in organic solvents; and a gas-fired surface combustion furnace was purchased for high temperature fusion of ash tests. Apparatus designed and constructed in the laboratories included a molybdenum wound, electric resistance furnace for high temperatures; a constant temperature chamber; a coal sample air-drying apparatus; apparatus for mixing heated coal; a large rheostat; and devices for extraction of coal by solvents.

SOUTHERN ALBERTA COAL SURVEY.

This coal survey, which was described at length in the 1930 Report, p. 16, was continued during part of 1931 mainly with respect to solubility in organic solvents. This work has not yet been completed.

Curves were plotted showing the variations of the proximate and ultimate analyses of these coals with the ash percentage of the sample. Fusion of ash tests were completed for this survey. Determination of the softening and decomposition temperatures of the coking coals have yet to be made. Dr. E. H. Boomer completed hydrogenation tests, in two different suspension media, on these coals; and the Fuels Division of the Mines Branch at Ottawa completed and reported low temperature carbonisation tests.

CENTRAL ALBERTA COAL SURVEY.

A coal survey, similar to the Southern Survey already described was commenced during October. The Department of Mines at Ottawa and the Provincial Mines Branch cooperated as before. The former sent a member of their staff Mr. W. P. Campbell, to take the samples and every sample was taken under the supervision of the District Inspector of Mines, or of Mine Inspector Mr. J. A. Richards. The districts sampled included Nordegg, Saunders, Big Valley, Three Hills, Carbon, Drumheller, Wayne, East Coulee, Castor and Sheerness. Seventeen sets of samples were taken and, as before, samples were also sent to Ottawa. The work on this survey is still in progress.

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[2] Moisture Determination for Coal Classification, by E. Stansfield and K. C. Gilbart. Trans. A. I. M. and M. E., Coal Division, 1932.

SLACKING CHARACTER AND FRIABILITY OF COAL.

In the earlier work, described on p. 18 of last year's report, a five-cycle test was made, and an index number devised. The United States Bureau of Mines, where the test originated, now employ one cycle only, but subtract from the observed loss the blank obtained by screening a duplicate sample without weathering. The corrected loss, expressed as a percentage of the weight taken, is the desired index of the slacking character. Tests were made during 1931 by the later method, but some samples were tested in both ways in order to correlate the two methods. The change to the one-cycle test permits a great saving of time and work. No change was made in the tests for friability previously described, but this test is still under consideration for final standardization.

ASH FUSION.

This work was continued during the year without change of method. Particular attention was given to variations of fusibility between different samples from the same mine.

The furnace used to date was only satisfactory for test up to 2600°F, although tests were made up to 2800°F. A small molybdenum wire electric resistance furnace was designed and constructed in the laboratory and a larger, gas-fired, surface combustion furnace was purchased. Both of these are intended for higher temperatures, but neither has yet been used.

SPECIFIC GRAVITY OF COAL.

Volume weight-ash relation charts, showing the specific gravity, cubic feet per ton and tons per acre foot, have been prepared for 26 coal areas. Some of these as yet contain too few points to be of real value, but curves can be supplied to those desiring them for the following areas: Big Valley, Carbon, Cascade, Castor, Champion, Coalspur, Crowsnest, Drumheller, Edmonton, Lethbridge, Magrath, Milk River, Mountain Park, Nordegg, Oldman, Pakowki, Pincher, Redcliff, Saunders, Sheerness and Taber.

SOLUBILITY OF COAL IN ORGANIC SOLVENTS.

Satisfactory methods were developed only after considerable initial difficulty. Many tests were made but no completed series of tests is available for publication. High pressure extractions with benzene and with benzene-alcohol mixtures were made at 200°C and about 40 atmospheres pressure. This work was made on samples of 250 grams weight in a special design, Cook, stainless steel autoclave purchased in England. Atmospheric pressure extractions were made in two types of glass apparatus developed for low and high-boiling solvents respectively. Studies were made of the effect of different gases in the extraction chamber and comparative tests with different solvents. Other work has interrupted this investigation.

BRIQUETTING.

When coals with coking properties are heated to about 400°C (750°F) certain constituents liquefy and, in the manufacture of coke, serve to bind the coal particles to form the coherent mass known as coke. Attempts have from time to time been made to employ this liquefiable material for briquetting heated coal. It is necessary that the coal should be heated in such a way that it reaches the briquetting press without serious decomposition. Heaters and mixers were constructed for treating coking coal alone or with lignite char, but the results were so discouraging that further attempts were abandoned. This process is difficult to test on a small scale and neither of the presses available was found suitable.

COAL CLASSIFICATION AND CUSTOM TARIFFS.

The sub-bituminous and domestic coals of Alberta, classified as lignite and lignitic coals under the Canadian Customs regulations, have in recent years been admitted duty free into the United States. This is under a reciprocal arrangement as the Canadian tariff admits such coals duty free. A decision of the United States Treasury, published in September, ruled that Lethbridge coal was bituminous coal and therefore liable to duty (75 cents per ton). The matter was brought to the attention of this Division, and action was taken to obtain a reconsideration. This was successful, as in December a further order was issued exempting from U. S. Customs duty coal produced in the Lethbridge district. This exemption does not include the special tax equal to the one per cent Canadian Special Excise Tax.

The Alberta coals classed as sub-bituminous, and even some coals classed as domestic, by the Provincial Mines Branch, and classed as lignitic by the Canadian Customs regulations, would normally be classed as low rank bituminous by the United States Geological Survey. The classification of coal is still in a chaotic condition.

MISCELLANEOUS INVESTIGATIONS.

An investigation of fire hazards with metal sheeted wooden buildings was carried out for the Attorney General's Department.

A study was made of the effect of moist and dry sulphur dioxide and of sulphuretted hydrogen, alone and together, on copper and other metals. The resistance of paints, asphalts, etc., to these gases was also investigated.

Combustion tests were made for the Trade Commissioner of Alberta on Alberta charcoal and on charcoal briquettes. They were each tested for duration and regularity of burning in a railway box car heater. Increased orders for Alberta charcoal were obtained as a result of this work. Tests were also made on the smokelessness of this charcoal.

Two news letters to the Coal Operators were issued during the year. The first of these, No. 6, gave a summary of the published information on the low temperature carbonisation of Alberta coals; the second contained reviews of recent books and articles on the technology of coal and the coal industry.

Hydrogenation tests on thirteen Alberta coals were completed by Dr. E. H. Boomer, as described in his report on Natural Gas Research.

Some micro-sections of Southern Alberta coals were made and photographed.

GEOLOGICAL SURVEY DIVISION

J. A. Allan.

Field work during the season has included detailed examinations in a number of areas and in addition reconnaissance examinations in other areas.

Detailed examinations on the geology and on the occurrence of various minerals have been made in the following areas:

1. Cochrane—Building stone.
2. Burmis—Iron.
3. Mowitch and Rock Creeks—Gypsum.
4. Athabaska Valley—Geology (Phosphate and Gypsum).
5. Pembina River—Geology.
6. Battle River-Meeting Creek—Coal, etc.
7. Willow Creek—Coal, etc.
8. McLeod River—Clay.
9. Elbow River—Volcanic Dust.
10. Tonquin Valley—Graphite.

Reconnaissance examinations included the following areas:

11. Burmis Area north to Oldman Gap.
12. Burmis Area south to Beaver Mines and Waterton.
13. Lethbridge vicinity.
14. Junction Red Deer and Peace Hills sheets on Battle River.

Notes are given below on the results of the detailed surveys insofar as is possible at the present time. More detailed studies will be made on the composition and analyses of the iron-bearing rocks from Burmis and also on the composition and character of the gypsum rocks.

The analyses in the iron specimens show that the rock carries a high titanium content. It is intended to determine the form in which the titanium occurs in these rocks. Some of the iron is in the form of magnetite, but it will be necessary to determine if some of the iron is in the form of ilmenite.

Reconnaissance examinations were made in certain areas and much valuable geological information was obtained relative to the structures connected with the occurrence of petroleum and coal.

Requests for geological information, related to the mineral resources and water resources of Alberta have increased during the year.

The office was closed during the summer from the first of June until the first of September. Mrs. M. Sandin, who acted as assistant in the office, resigned in May. Early in September, Miss Gladys Speer was appointed as stenographer for this office.

The drafting duties have been carried out satisfactorily by P. F. Parsons. Drafting work has also been undertaken for other divisions of the Research Council.

Dr. P. S. Warren has again cooperated with the Geology Division in determining palaeontological material collected during the field surveys. He also undertook some field work for this Division in the Willow Creek, McLeod River and Athabaska Valley areas. Courses of instruction and other assistance were given to the Department of Geology at the University of Alberta by Dr. R. L. Rutherford.

Special investigations conducted by this Division have included a detailed microscopic examination on rock dust and shale from Bellevue Mine. This study formed part of a more detailed investigation into the suitability of certain rock from Crowsnest district to be used for rock dusting in coal mining operations.

Early in the year the annual report on the work in the Geological Survey Division was prepared and this has been published as part of Report 26. No special reports of the work of this Division have been published during the year although the manuscripts are practically completed for three different reports. Progress can be reported on the compilation of a revised geological map of Alberta. This map should be ready for publication in 1932. The compilation of water supply data has progressed rather slowly, but many requests for advice on local water supplies have been received and considered in so far as it has been possible with the geological data on hand.

I have given most willingly considerable time during the year to Mr. William Calder, Director of the Petroleum and Natural Gas Division of the Department of Lands and Mines, in connection with the geological matters in his Division. It is with pleasure that I record the most friendly cooperation and coordination between the Petroleum and Natural Gas Division and the Geological Survey Division of the Research Council of Alberta in matters relative to the geology of Alberta.

1.—COCHRANE BUILDING STONE SURVEY.

Sandstone quarries for the extraction of building stone have been opened, worked for a time and then abandoned during the past thirty years in the vicinity of Cochrane, Alberta. The abandonment of these quarries has been for a two-fold reason. Firstly, the lack of market, and secondly, the lack of induration of the sandstone, chiefly on account of the age of the rock which is young.

Renewed interest was taken in building stone in the Cochrane district two years ago, when Mr. William Oliver of Calgary, opened up a new quarry and the stone from this quarry was used in the construction of the east addition to the Canadian Pacific Railway station at Calgary. A building in Drumheller has also been constructed with the stone. After exposure in the buildings for one winter the stone appeared to be more durable than stone previously used from quarries from the same district.

In April I made an inspection of the stone in the railway station in Calgary, and also visited the quarry at Cochrane with Mr. William Oliver and Mr. S. H. Porter, of the Canadian Pacific Railway Natural Resources Branch in Calgary. Observations in the field and preliminary tests warranted more detailed examinations, with the result that a detailed survey of this building stone was included in the programme of the Geological Survey Division in 1931.

Location. The building stone outcrops on the north bank of Bighill creek which is a tributary to Bow River. This creek enters the river just west of the town of Cochrane on the Canadian Pacific railway, 22 miles west of Calgary. A graded road extends north from Cochrane over the west shoulder of Cochrane hill, to the crossing of Bighill creek. There is a good road up the bottom of Bighill creek and past where the sandstone beds outcrop. There are five abandoned quarries in Bighill creek, and the sixth quarry is the one which has been worked recently by Mr. Oliver.

This quarry, which for convenience of reference is called the Oliver quarry, is 3.8 miles by road from Cochrane railway station. The location of the quarry is in legal subdivision 9, section 18, township 26, range 4, west of the 5th meridian. The other five abandoned quarries are in the northeast quarter section 11, township 26, range 4.

Plan of Survey. In May a survey party was placed in the field to take levels on the sandstone and to make a contour map of the north side of the valley of Bighill creek from the bridge for about 3½ miles up stream. During my absence R. L. Rutherford assisted by H. H. Beach made a geological examination, and G. E. Moody conducted a stadia survey. Other members of the party consisted of J. Tatham and W. Hole as rodmen.

A topographical map was made of the north side of Bighill creek for a distance of approximately four miles from the bridge over Bighill creek. The map is on the scale of one inch to 200 feet, with a contour interval of 10 feet. Levels were run on the prominent sandstone beds, sections of the rock succession were measured at various points, and the character of the sandstone observed. This survey required about three weeks. In August I made an examination of the area mapped, added further details on the character of the rock and sampled the most prominent sandstone bed at six different points.

Geological Relations. The strata exposed along Bighill creek belongs to the Paskapoo formation, which is Lower Tertiary in age. This is the youngest rock formation in central Alberta. On account of the young age of the strata, these rocks in Bighill creek are soft in comparison to the older and more indurated rocks. The succession of strata consists of interbedded sandstone and clay shales. Some of the sandstone beds are harder than others. There is also a wide variation laterally in the hardness of a single bed of sandstone, so that at one point the sandstone may be considerably harder. This is the case in the sandstone beds exposed along Bighill creek.

There are two and in some places three massive sandstone beds exposed on the north bank of Bighill creek in the area mapped. The position of all the rock outcrops have been mapped. Incidentally it must be mentioned that the aerial photographs of this district were valuable in determining the actual position of the rock outcrops.

In a later report on this area, when additional tests have been completed on this sandstone, details will be given on the character of the sandstone in all of the quarries and throughout the area mapped, but in this report attention is given only to the character of the sandstone in Oliver quarry.

Oliver Quarry. This quarry is situated on the east side of a small coulee and on the hillside 40 feet above the roadway, and about 150 feet in horizontal distance from the road. Plate I shows the position of the quarry and the topography in the vicinity of the quarry.

The section at the quarry is as follows:

1′0″—soil.
1′6″—shale and shaly sandstone.
3′6″—grey sandstone.
0′1″—clay shale.
5′2″—massive sandstone (quarried). Master joints on face of quarry strike N 20° W and dip 72°SW; and minor joints strike S 70° W and dip 85° to 90° W. There is a distinct parting at the bottom of this bed.
8′6″ to 9′0″—massive sandstone. In the lower 2′ the bedding is irregular.
2′0″—irregular sandstone, with many clay pellets, coal pebbles and clay ironstone nodules. Soft and not suitable for quarrying.
6′ to 10′—massive sandstone, crossbedded and soft on the outcrop. On the outcrop this bed is not suitable for quarrying, but it might be better in quality in from the outcrop. This bed looks like a better building stone up the coulee and on the west bank. If so there may be a block of 50 to 100 yards available with less than 15 feet of cover. Below this bed the strata are not exposed at this location.

This quarry has been started on the best part of the 5-foot 2-inch bed that is exposed here, because this bed is of irregular character and composition on the outcrops both to the east and to the west, although the same bed can be traced for a mile in both directions.

The overburden is from 6 feet to 25 feet for a distance of about 30 yards north and then the surface rises with a steep slope for about 170 feet. However, the quarry bed has a cover of 0 to 25 feet along the hillside for at least 100 yards.

In this one bed alone that has been opened up east of the coulee, assuming an average thickness of 5 feet, a length of 1,000 feet and a depth of 90 feet, there are approximately 50,000 cubic yards of stone with less than 25 feet of cover, which if all like the exposure in the quarry can be classed as suitable for building stone.

One noteworthy feature about this stone is that it does not appear to discolor or soften on the exposed or weathered surface. On the outcrop at the quarry, where the surface has been exposed to many years of erosion, the fresh uncolored stone occurs at the surface.

Composition and Analysis. Thin sections of this rock are now being prepared for microscopic examination, to determine if there are any minerals present detrimental to the weathering properties of the dressed stone. Such minerals have not been observed microscopically.

A chemical analysis of an average sample of the sandstone from the 62-inch bed in the quarry was made by J. A. Kelso, in the

Industrial Laboratories at the University of Alberta and gave the following results:

Silica	73.64	per cent.
Alumina	3.50	" "
Iron oxide	2.80	" "
Lime	8.36	" "
Magnesia	2.74	" "
Ignition loss	9.49	" "
Total	100.53	

This is a good quality of sandstone with a small content of lime, magnesia, alumina and iron.

Physical Tests. Chemical tests are important to determine the composition of the rock, but the physical tests are of great importance in determining the suitability of the rock for building purposes.

J. A. Kelso reports on physical tests made in the Testing Laboratories at the University of Alberta, as follows:

Specific gravity, rock substance	2.602
" " rock in bulk	2.264
Weight per cubic foot in pounds	141
Pore space, per cent.	12.98
Ratio of absorption, per cent., one hour	4.84
" " " two hours	4.92
" " " in vacuo	5.52
Crushing strength, lbs. per sq. in., dry	8360
" " " " wet	5170
" " " " after freezing	5460
Transverse strength, modulus of rupture	865

Blocks of the stone will be subjected to natural freezing and thawing tests.

Comparing the physical and chemical tests that have been made on this stone and taking into consideration the structural conditions in the bed relative to quarrying facilities, I am of the opinion that the sandstone in the Oliver quarry is a satisfactory building stone.

2.—BURMIS IRON.

Introduction. The occurrence of iron-bearing rocks in the Burmis district has been known for a number of years. In the Summary Report of the Geological Survey of Canada for 1911, W. W. Leach reported on the occurrence of this iron which was being prospected at that time.

In 1919 I visited the south end of the occurrence and collected samples. The analyses of these samples and some notes on the deposit were included in the Research Council Report No. 1, page 62. Since then the question of possible economic utilization of these iron-bearing rocks has been raised at various times. It was essential that a detailed examination of the extent and character of these deposits be made, in order to determine the economic possibilities. In 1931 with the completion of the survey on Cochrane building stone the party was transferred to the Burmis district and the following notes deal with this survey. I was assisted by R. L. Rutherford in this survey.

Location. Burmis station is on the Crowsnest branch of the Canadian Pacific railway, nine miles east of Blairmore. This district is within the foothills which are here characterized by a series of sub-parallel ridges with a general north-south trend. These ridges rise about one thousand feet above the intervening valleys.

The iron-bearing rocks examined, outcrop at several places in these ridges north of the railway. The most southerly outcrops occur about half a mile north of Burmis station. The most northerly outcrops examined occur about ten miles north of Burmis station.

Geology. The foothills north of Burmis consist largely of folded and faulted strata of upper Cretaceous age. Two formations, namely, the Benton (marine shales) and the Belly River (freshwater sandstones and shales) form the underlying rocks in a large part of the foothills. The Belly River formation is more prevalent in the ridges because of its greater hardness and the iron-bearing beds occur within the lower part of the Belly River formation. Several sub-parallel ridges of Belly River rocks occur within this general district, but the iron-bearing beds are confined to one ridge, which extends from the valley side near Burmis station, north along the east slope of the Livingstone range. The Livingstone range, consisting largely of Upper Palaeozoic beds has been over thrust upon a westerly dipping succession of Belly River and Benton beds. Subsequent erosion has removed the Benton to lower levels east of this range exposing the lower Belly River beds which carry the iron.

The iron-bearing beds are exposed at several places within the belt of Belly River strata. The best exposures occur at the south end near Burmis station and to the north in front of the Livingstone range, in the north part of township 8, range 3. Our surveys were confined to these two areas as shown on the accompanying map. Plate II.

The southern area was examined in detail particularly on account of its proximity to railway transportation and also because it has been quite extensively prospected. The northern area surveyed although somewhat removed from the railway, had been considerably prospected some years ago. These two areas include the most promising occurrence of iron-bearing beds exposed in the Burmis district.

Surveys. Maps available did not contain sufficient topographical details to be used for mapping the iron-bearing bed, and it was necessary for us to survey certain parts in detail. Instrument surveys were carried on in the southern and northern areas. Topographical maps on a scale of one inch to 200 feet, and contour interval of 20 feet were made from these surveys. These maps were used to show the position of the various iron-bearing beds and associated strata.

Southern Area. The area mapped covers almost 480 acres and lies principally within the west halves of sections 2, 4 and 25, in Township 7, range 3, west of the 5th meridian.

In this area there is one main iron-bearing bed extending north and south. It has an average dip of 35 to 40 degrees to the west. There are a number of open cut prospects in the southern area.

The most promising occurrences are shown in prospects in legal subdivision 12 of section 24.

In some of the open cuts the iron bands appear to have a thickness up to ten feet, but on closer examination these apparent thicknesses are found to be due to folding. The maximum thickness of the iron-rich bed is between three and four feet. There are usually beds lower in iron content associated with the richer phases. The general appearance of these on the weathered surface is similar to the richer phases, and unless a close examination is made, the difference would not be detected and all might be considered iron-bearing. Furthermore, where the beds are duplicated by folding the richer and leaner beds become intermixed to such an extent that it is difficult to differentiate between them. This also suggests a thicker deposit than actually exists. There are other sandstone beds that contain considerable iron, but their lateral extent is irregular.

Northern Area. The area mapped covers about 1,440 acres lying principally in the east half of sections 22, 27 and 34, township 8, range 3, west of the 5th meridian. In this area there are several iron-bearing beds, but only one of these was sufficiently rich in iron to warrant a detailed examination, although the outcrops of the richer phases of two other beds were examined and mapped.

This area has been most extensively prospected by open cuts and one tunnel 100 feet in length, in northeast quarter section 22, township 8, range 3, west of the 5th meridian. The main bed at these prospects has a maximum thickness of 15 feet and dips southwest at 20 to 25 degrees. In some places as much as 20 feet of beds below the richer zone are iron-bearing, but the lateral extent of these is irregular. The richer phases of the underlying and the overlying iron-bearing beds have been sampled and analysed. The richest bed lies between the two other leaner beds, and separated from the lower bed by 125 feet and from the upper bed by 250 feet.

Analyses. Chemical analyses have been made from twenty-one samples. Ten of these samples were taken in the south area and the other eleven samples were from the north area, so that the analyses may be regarded as representing the average tenor of this iron-bearing rock.

The analyses show that in twenty of the samples the metallic iron content ranges from 14.70 per cent. to a maximum of 54.88 per cent. At the same time the silica content ranges from 4.84 per cent to a maximum of 45.20 per cent. The analyses also show that the iron-bearing rocks are all titaniferous, as the titanium oxide content varies from 4.62 per cent to a maximum of 12.02 per cent. One sample shown in the analysis 18, only carries 7.54 per cent metallic iron, so is not representative of the iron zone.

This ore is classed as a siliceous titaniferous magnetite. The iron occurs as irregularly rounded grains and forms one of the mineral constituents of the sandstone. It would appear that the iron grains were deposited as magnetite sand along the beaches in the Belly River time.

One of the main problems related to this iron deposit is the high titanium content. It is our intention to investigate in the

ANALYSES OF IRON–BEARING ROCKS, BURMIS, ALBERTA

Samples analysed by J. A. Kelso, Industrial Laboratories, University of Alberta, November, 1931.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No.9	No. 10	No. 11	No. 12	No.13	No.14	No.15	No.16	No.17	No.18	No.19	No. 20	No.21
Silica	45.20	20.50	20.50	8.02	11.02	6.02	8.30	38.30	13.62	4.84	6.48	6.56	17.56	6.96	13.14	28.06	8.54	47.44	36.34	11.58	27.38
Iron Oxide	21.00	49.94	49.90	75.14	70.80	70.60	74.19	31.50	60.88	78.40	70.87	64.79	47.92	76.18	69.18	42.99	66.96	10.77	29.34	70.87	56.99
Titanium Oxide	4.62	7.06	7.42	8.16	7.82	7.90	6.58	5.08	8.18	6.80	7.66	6.80	8.26	7.62	8.50	8.82	9.54	2.00	7.50	12.02	10.14
Alumina	5.02	....	4.17	....	....	....	....	....	7.44	....	....	....	....	....	....	....	....	....	....	....	....
Lime	7.06	3.86	4.68	3.86	2.42	3.86	....	....	2.50	....	....	....	....	....	....	....	....	....	....	....	....
Magnesia	5.46	3.34	2.63	1.65	1.04	.74	....	....	1.50	....	....	....	....	....	....	....	....	....	....	....	....
Manganese Dioxide	.23	....	.29	.31	.36	....	....	....	.39	....	....	....	.34	.25	....	....	.25	....	....	.36	....
Ignition Loss	9.42	....	8.80	....	....	....	....	....	4.74	....	....	....	....	....	....	....	....	....	....	....	....
Phosphorus	....	....	.194	.182	.205	.168	....	....	.237	.225	....	....	....	....	....	....	....	....	....	....	....
Sulphur	....	....	.166	.164	.226	.192	....	....	.108	.109	....	....	....	....	....	....	....	....	....	....	....
Equivalent of iron oxide in metallic iron	14.70	34.95	34.93	52.59	49.56	49.42	51.93	22.05	42.61	54.88	49.60	45.35	33.54	53.32	48.42	30.09	46.87	7.54	20.54	49.60	39.89

SOUTH AREA.

1. Channel sample from iron zone east of Boutry's gate, Ls. 3–24–7–3–W.5th.
2. Picked specimen, same locality as (1).
3. Channel sample from iron zone in west prospect just north of E–W centre line in Sec. 24-Tp. 7–R. 3.
4. Specimen sample from prospect in (3).
5. Channel sample from iron zone east prospect in Ls. 11–Sec. 24–Tp. 7–R. 3–W.5th.
6. Picked sample from same locality as (5).
7. Specimen sample from same locality as (5).
8. Specimen sample from prospect at station 24 in Ls. 14–Sec. 24–Tp. 7–R. 3.
9. Average sample from iron zone in north prospect in Ls. 12–Sec. 25–Tp. 7–R. 3.
10. Specimen sample from same locality as (9).

NORTH AREA.

11. Picked specimen from dump at mouth of entry to prospect tunnel, Ls. 15–Sec. 22–Tp. 8–R. 3–W.5th.
12. Specimen sample from same locality as (11).
13. Banded ore specimen from same locality as (11).
14. Specimen sample from prospect at station 18 in Ls. 10–Sec. 22–Tp. 8–R. 3.
15. Channel sample from prospect at same locality as (14).
16. Channel sample from prospect on nose of hill just south across draw from No. 12 locality.
17. Specimen sample from base of main ore zone in same prospect as (16).
18. Specimen sample from No. 1 iron zone on nose at east of main tunnel referred to in (11) and south of station 10 in Ls. 2–Sec. 27–Tp. 8–R. 3.
19. Average sample, same locality as (18).
20. Specimen sample from No. 3 iron zone upper part of slope below station 10 in Ls. 2–Sec. 27–Tp. 8–R. 3.
21. Channel sample from base of No. 3 iron zone below station 10.

laboratory the samples collected, and to determine the form in which the titanium occurs. Thin sections of the iron-rich rock are now being prepared and these will be examined microscopically. Polished specimens of the ore are also being studied, and by these methods it will be possible to find out if the titanium occurs as an impurity in the magnetite or as one of the titanium minerals. This is important and necessary before any metallurgical tests are made on the ore.

The quantity of iron-rich rock in the deposit is relatively small. The deposit is an interesting occurrence of iron, but at the present time it cannot be regarded as a commercial deposit.

3.—Mowitch and Rock Creeks: Gypsum.

Specimens and samples of high grade gypsum from the Rocky Mountains have been received in my office at different times since 1912. The exact locality had not been ascertained, but it was supposed to occur north of Jasper Park. Early in 1931 gypsum claims were staked and twelve claims recorded in the Provincial office of the Department of Lands and Mines, in Edmonton. These claims on the records were shown to occur in township 52, range 5, west of the 5th meridian and north of Jasper Park.

In August, 1931, two weeks were spent on a trip with pack horses to the gypsum deposits. I was assisted by R. L. Rutherford and was accompanied by four other men. The route followed was from Entrance station north up Solomon creek to Rock Lake, then west up Hay river, across Eagle's Nest Pass to Rock creek. From mile 58 on the Forestry trail we went west into the valley at the back of the range that forms the west side of Rock creek valley. Two of the men with me, Mr. Donald McDonald and Mr. Frank Corser, had staked part of this group of claims so that no time was lost on reaching the gypsum deposits.

Location. The gypsum deposits are situated on the east slope of a valley, tributary to Mowitch creek, which flows into Rock creek in township 51, range, 4, west of the 5th meridian, and about three miles southwest from Rock creek.

On the plans filed in the office of the Department of Lands and Mines the claims are shown to be in township 52, on the east side of range 5. I saw most of the claim posts. Most of the claims are in township 51, range 5. The exact position is not known, as the country is not surveyed, but I obtained a plan of the Canadian National railway location up Rock creek, and this plan enabled me to get the approximate position of the claims.

We spent about a week examining the gypsum deposits and returned by way of Deer creek and Snake Indian river to the Athabaska at Devona. I enquired from the Superintendent of Jasper Park as to the exact position of the north boundary of Jasper Park, and was assured that the creek where the gypsum claims occurred was north of the Park boundary.

On my return to Edmonton I consulted the Statutes of Canada, 1930, Chapter 33, page 10, and from my knowledge of the geography of that part of the country, I am convinced that the gypsum claims are all within the boundary of Jasper Park, with the possible exception of the north part of the most northerly claim. The mistake in location is due to the very inaccurate maps of that part of Alberta along the north boundary of Jasper Park.

Plate III shows the approximate position of the gypsum claims, the corrected positions of Rock and Mowitch creeks and the north boundary of Jasper Park as interpreted from the Statutes of Canada, 1930.

The gypsum occurs in beds of Triassic age. The strata are all steep dipping and in places are nearly vertical. The rock succession consists of beds of pure white gypsum and lenses of gypsum, interbedded with impure gypsum, chert and shale intermixed and other beds of red, buff, yellow, brown and grey limestone, siliceous and cherty limestone, quartzite and shale.

On the whole the series of rocks with which the gypsum is associated may be called Triassic red and yellow beds. Many sections were measured and examined in detail and a large number of samples collected.

The thickest bed of pure white gypsum examined measured about 12 feet, but much thicker beds of gypsiferous rock occur. In one coulee at the southern end of the deposit there is a series of badly broken impure gypsum and chert beds that measures almost 200 feet in thickness. But the gypsum content is too low in these beds to be considered of economic importance.

The purest gypsum is lensy in character, that is the bed changes character laterally, so that although samples of pure gypsum can be obtained, yet the quantity of this quality of mineral in one bed was not found to be large.

Analyses. Seventeen of the samples collected have been analysed. After these analyses have been studied in conjunction with their location in the deposit, other samples may be analysed.

The table given below contains the results of 17 analyses made by J. A. Kelso, in the Industrial Laboratories at the University of Alberta. It will be seen from these that a number of analyses represent a pure quality of rock gypsum, but many are quite impure and some can not be classed as gypsum beds.

The following is the table of analyses:

ANALYSES OF GYPSUM-BEARING SAMPLES COLLECTED BY J. A. ALLAN FROM EAST SIDE OF A BRANCH OF MOWITCH CREEK IN TOWNSHIP 51, RANGE 5, WEST OF THE 6th MERIDIAN. AT NORTH BOUNDARY OF JASPER PARK, ALBERTA.

Analyses made by J. A. Kelso, Director, Industrial Laboratories, University of Alberta, September, 1931.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	No. 17
Siliceous residue	1.51	3.40	3.10	1.51	.89	.82	83.14	11.91	2.02	3.30	63.90	13.82	19.52	3.88	39.44	1.91	.00
Iron Oxide and Alumina	.59	.81	.00	.49	.00	.00	1.56	.40	.90	.00	1.24	1.00	1.05	.92	2.86	.32	.00
Lime	32.12	31.39	32.40	31.90	32.22	32.28	7.50	27.80	31.21	31.08	18.20	28.11	26.65	31.42	31.04	32.02	32.68
Magnesia	1.10	5.40	2.31	1.41	.00	.00	.84	1.51	.78	.58	.00	5.95	9.71	5.75	8.48	.00	.00
Sulphuric Anhydride	43.38	35.71	41.42	43.28	46.02	45.91	.90	38.42	44.34	44.58	1.72	30.80	17.30	36.31	1.22	45.83	46.58
Ignition Loss (Water, etc.)	21.40	23.20	20.70	21.51	20.90	20.80	5.85	19.90	20.90	20.27	14.78	20.30	25.80	21.42	16.69	20.00	20.82
Gypsum Calculated from Sulphuric Anhydride	93.09	76.63	88.88	92.88	98.75	98.52	1.93	82.44	95.15	95.67	3.70	66.10	37.12	77.91	2.62	98.35	100.00

(1) Channel sample 3 foot bed. McDonald Gulch.

(2) Channel sample 29-inch bed, 1 foot below No. 1. McDonald Gulch.

(3) Specimen sample from bed 9 feet, 7 inches. McDonald Gulch.

(4) Channel sample from bed 9 feet, 5 inches. McDonald Gulch.

(5) Average sample from upper part of bed in No. 4. McDonald Gulch.

(6) Average sample from lower part of bed in No. 4. McDonald Gulch.

(7) Specimen sample from mass of buff sandstone at base of gypsum-bearing strata. East branch McDonald Gulch.

(8) Channel sample from 7 foot gypsum bed. East McDonald Gulch.

(9) Specimen sample from 12 foot bed, 5 feet above No. 8. East branch McDonald Gulch.

(10) Average sample from 13 foot bed white gypsum bed in Corser Gulch near south end of property.

(11) Specimen sample from hard cherty band below No. 10. Corser Gulch near south end of property.

(12) Channel sample across 10 feet crushed gypsum-bearing beds. Corser Gulch near south end of property.

(13) Channel sample across 15 feet of beds immediately above No. 12. Corser Gulch near south end of property.

(14) Average sample from 20 feet of strata below No. 13. Corser Gulch near south end of property.

(15) Average sample from gypsum horizon. Mt. Cinquefoil, Athabaska Valley.

(16) Average sample from bed 9 feet, 7 inches. Same as No. 3.

(17) Specimen from lens white gypsum. East branch McDonald Gulch.

4.—ATHABASKA VALLEY GEOLOGY.

An investigation of the rocks exposed along Athabaska river west of Brule was undertaken for the purpose of obtaining a better understanding of the character of the rocks and rock succession in that area. This succession of rocks is the key to the strata underlying the plains area at depth. These rocks are important as being possible sources of oil and gas in certain districts. They have been pierced by the drill in several holes in central Alberta, but it is difficult to obtain any definite knowledge of their general character or economic possibilities from well samples.

The rocks in the succession examined are mostly of Palaeozoic age ranging from Cambrian to Carboniferous. Devonian and Carboniferous rocks, mostly composed of limestones, are of special significance because of the great thickness of these formations and on account of the known occurrences of these rocks below the plains region. Our understanding of the sub-surface geology of central Alberta has been greatly enhanced through this investigation.

Attention was also given to the occurrence of beds containing gypsum and phosphate in the area examined.

5.—PEMBINA RIVER GEOLOGY.

Part of the general programme of the Geological Division has had as its object the preparation of a general geological map of the central part of Alberta on a larger scale than those available at present. This necessitated an examination of certain districts, since the geological boundaries as shown on published maps are inaccurate in some places.

It had been planned that R. L. Rutherford should examine in 1931 certain areas along the Pembina and Athabaska rivers and districts to the south and east, but illness prevented this. One of the areas was examined, namely, that along the Pembina near its confluence with the Athabaska. It was found that the Belly River strata extends considerably further north than shown on published maps.

6.—BATTLE RIVER AND MEETING CREEK COAL, ETC.

In 1928 our Survey made an examination of an area lying between the Red Deer and Saskatchewan rivers. Previous surveys had been made of the area covered by the Red Deer and Rosebud sectional sheets to the south and of the St. Ann sheet to the northwest. The work of 1928 was done primarily to connect up the geology of the two separated areas. Most of this intervening area lies within the Peace Hills sheet (No. 265). The results of part of this work have been published in Research Council Report No. 24.

The work of 1928 left some points of correlation in doubt especially in the eastern part of the area covered by the Peace Hills sheet, and in 1931 two weeks were spent in obtaining further data in this part of the area. Instrumental surveys were made along parts of the valleys of Meeting Creek and Battle river in townships 41 and 42, ranges 16, 17 and 18, west of the 4th meridian.

The position of the contact of the Bearpaw and Edmonton formations, the position and attitude of the coal seams along Battle river and Meeting creek were determined by instrumental surveys. The chief object of the instrumental work was to determine the regional dip of the strata and the stratigraphical horizon of the coal seams.

The coal seams are in the Edmonton formation in this district and are mined at a number of places in these two valleys. In addition to their value as coal seams they have an economic significance relative to the water supply. The Edmonton formation in this general area does not as a rule contain porous horizons which would serve as water-bearing beds that could be reached by bored wells, or drilled wells. In the Camrose district within the Peace Hills sheet it has been found that the coal seams appear to be the best water-bearing beds occurring within the stratified rocks underlying the district. Consequently a knowledge of the stratigraphical position of the coal beds and the regional dip of the strata are of value in determining the possible water horizons in this area. Requests for information relative to water horizons are increasing from time to time, especially in areas that are well settled and developed.

Our examination of the district has shown that the strata are almost flat-lying, with a small regional dip to the southwest. The coal horizons are in the lower part of the Edmonton formation corresponding in general to the stratigraphical position of the seams mined at Drumheller, Rosedale and Wayne.

7.—WILLOW CREEK COAL, ETC.

Additional information was obtained in the field on recent development at the various coal mines in the Willow creek district, in the Red Deer valley south of Drumheller and Rosedale. These notes are incorporated in the report on the Red Deer and Rosebud sheets awaiting publication as Report 13 of the Research Council. This examination has added to our knowledge of the correlation of coal seams as mined in the Red Deer valley.

8.—McLEOD RIVER CLAY.

A short investigation in conjunction with Mr. Hugh S. Spence of the Mines Branch, Department of Mines, Ottawa, of the clay deposits on the McLeod river in sections 6 and 7, township 52, range 18, west of the 5th meridian, was undertaken for the purpose of ascertaining the economic possibilities and geological occurrences of the deposits in that area. The deposit proved to be bentonite with considerable intermixture of silt. The bed outcrops at stream level and is at least three feet thick. It is overlain by 10 feet of brownish and variegated clays capped by about 20 feet of heavy sandstones, all belonging to the Saunders formation.

The clay is being utilized commercially by the Claynett Products, Ltd., of Edmonton.

9.—TONQUIN VALLEY GRAPHITE.

Samples of graphitic rock have been received at this office at different times. These samples were reported to have come from western Alberta, within Jasper Park.

During the summer of 1931 I examined this occurrence with Mr. Donald McDonald, who has prospected the deposit. The following notes describe the graphite occurrence.

The graphitic rocks outcrop above timber line at 7,000 feet in a creek in the southwest corner of township 44, range 2, west of the 6th meridian. This creek joins Meadow creek from the east at the north end of Tonquin Valley, 10 miles south of Geikie station on the Canadian National Railway in the Miette Valley between Jasper and Yellowhead Pass.

The rocks are Precambrian slates, phyllites, schists, quartzites and pebble conglomerates. The graphite occurs in slates that are intensely metamorphosed. Carbonaceous slates are wide spread and those higher in carbon have developed into graphitic schists.

The best exposure is near timber line at 7,000 feet in the creek bed. The beds strike about north 80° west and dip 80° south. The hanging wall is thin bedded quartzitic sandstone and arenaceous slates. The graphitic zone measures 20 feet and is underlain by less graphitic arenaceous slates. There are nodular bands of marcasite up to 1 inch in thickness.

Five samples were taken of the graphitic zone as follows:

1. Large channel sample across up 10 feet.
2. Graphitic mud from weathered graphitic slates.
2. Very graphitic mud sample from 2 feet from roof.
4. Graphitic slates across 12 to 15 feet from roof.
5. Graphite slates in the lower ten feet of zone.

A chemical analysis of the richest looking material showed that the carbon content was very low in these graphitic schists.

Near the head of the creek at 7,500 feet above sea level there is another outcrop of graphitic slates, but not over 3 feet in width. The richest bed is about 6 inches. Sample No. 6 was taken from this outcrop. The dip here is 20° north and the strike about north 70° west. I do not think this is the same zone as at the outcrop 500 feet lower down. The graphitic slates cross at the east end of Maccarib Pass.

10.—ELBOW RIVER VOLCANIC DUST.

In April I examined fresh exposures of Paskapoo rocks made during the excavations for the Glenmore dam then under construction for the City of Calgary, on the Elbow river south of the Country Golf Course. In the course of this examination I discovered a bed of volcanic dust in the alluvial deposits immediately above the bedrock. The dust bed varies in thickness from the fraction of an inch up to about 10 inches, and in places the dust is intermixed with clay.

The volcanic dust is white to creamy colored and is fine in texture with a harsh feel. Under the microscope it consists of many angular chards of glass and extremely finely divided dust.

The samples, analysed by J. A. Kelso in the Industrial Laboratories at the University of Alberta, gave the following analyses:

	No. 1	No. 2
Silica (SiO_2)	66.20	66.40
Alumina (Al_2O_3)	15.40	17.00
Iron Oxide (Fe_2O_3)	5.40	3.50
Lime (CaO)	4.39	4.39
Magnesia (MgO)	.10	.14
Phosphoric Acid (P_2O_5)	.18	.12
Ignition Loss (Water and organic matter)	5.54	6.56
Potash and Soda (K_2O and Na_2O)	2.79	1.89

This dust has definite cleansing properties. This is one of the chief uses for this kind of mineral product. As this dust bed is exposed on the upstream side of the dam, the outcrop will be covered with several feet of water when the reservoir is filled. However, the quantity of volcanic dust in this bed is very small. In subsequent visit to this site the same dust bed has been found below the dam.

The discovery of this dust bed is also of scientific importance, because it indicates that there were active volcanoes in recent geological time. The source of this volcanic dust is not known, but it has probably been transported by wind from the mountainous country, possibly in central British Columbia.

ROAD MATERIALS DIVISION

K. A. CLARK AND D. S. PASTERNACK.

The last annual report recorded the success achieved in the operation of a semi-commercial plant in the North under the practical conditions at the bituminous sand deposits. The report also dealt with preliminary studies of some unexpected difficulties encountered in the north and predicted that progress following out of these difficulties was likely to be more valuable than the substantial success of the large plant. Further studies have amply confirmed this prediction.

Chance has played an interesting part in bringing about the progress which has been achieved. The Federal Department of Mines located its bituminous sand quarry, beside which the Research Council of Alberta agreed to build and operate a separation plant, at what it considered the most convenient place available. It did not know that the bituminous sand beds at this place were in any sense extraordinary. Yet they were. Ground water working through them from the clay overburden above had carried into them unusual quantities of soluble salts. The presence of these salts caused a very considerable amount of trouble in the separation plant. But in doing so they "gave away" the secret of bituminous sand separation. The Research Council has been trying for years to get its finger on the fundamental principle underlying this process. Its workers were well prepared to take advantage of the chance encounter with an abnormal condition at the northern bituminous sand quarry and to turn it rapidly into concrete knowledge.

The secret of bituminous sand separation by hot water turns out to be very simple. In the first place all bituminous sand contains acid. Sometimes there is very little and other times, due to the presence of iron salts, there is a very considerable amount. This acid must be neutralized by mixing the bituminous sand with an alkali before the sand will separate satisfactorily on washing with hot water. In the second place, lime in the bituminous sand must be avoided for it is a veritable poison for the separation process. Consequently lime cannot be used to neutralize the acidity of bituminous sand. Further, there is danger in using another common alkali, namely, caustic soda, for this will generate lime from calcium salts that may be present in the bituminous sand. Soda ash is the proper chemical to use. Generally speaking, if bituminous sand as found in Northern Alberta is mixed and heated with a solution of soda ash till all its acidity is neutralized and then washed in hot water *practically one hundred per cent* of the bitumen content of the same will be recovered.

These facts have been established by patient work in the laboratory during the past year. Three stocks of good clean bituminous sand were secured and used in the numerous experiments. First, the matter of acidity in the bituminous sand was investigated. Samples of bituminous sand were artificially made more acid and less acid than the natural material. All the samples were then separated in a laboratory-sized separation plant to see what the effect of the varying degrees of acidity was. In a similar way the lime contents of series of samples were artificially arranged and the effect on separation results determined. The effect of other things, such as iron salts, sodium sulphate and clay which are found in bituminous sand, were also examined and interesting information gained. However, acid and lime were found to be the substances which are of outstanding importance.

The effect of acidity can be seen by looking over the experimental data tabulated in Table I. Three bituminous sands were used. They came from places that were miles apart, and the coarseness of the sand and stiffness of the bitumen in them were quite different. So the results of the table can be considered as true for bituminous sand in general. The kind and quantity of acid or alkali added to each test batch of bituminous sand is given in the second column. The figures in the pH column show how acid or alkaline the bituminous sand was after the acid or alkali had been added. The value 7.0 indicates that the bituminous sand was neither acid nor alkaline, or in other words, that it was exactly neutralized. All figures less than 7.0 indicate acidity, and the smaller the figure the greater the acidity. Figures greater than 7.0 indicate alkalinity and the greater the figure the greater the alkalinity. The data in the last two columns show with all three bituminous sands that when the bituminous sand is distinctly acid the bitumen separated from it by washing with hot water is sandy and that the recovery of bitumen is poor. Recovery and freedom of the separated bitumen from sand improve as the bituminous sand becomes less acid, and when neutral of alkaline all the

TABLE I.

Results of tests to show the effect of the acidity or alkalinity of bituminous sand on its separation by means of hot water.

Preparation of bituminous sand for separation		Composition and yield of bitumen		
Reagents added to bituminous sand	pH	Water content of bitumen %	Sand content of bitumen %	Yield %
Bituminous Sand No. 1:				
0.026% Sulphuric Acid	3.1	12.8	17.6	50
0.013% Sulphuric Acid	5.2	14.3	4.4	60
Natural bituminous sand	5.9	11.3	3.8	75
0.040% Caustic Soda	6.7	17.0	2.4	99
0.065% Caustic Soda	8.3	19.6	2.6	100
Bituminous Sand No. 2:				
0.047% Sulphuric Acid	3.5	14.3	4.2	65
0.023% Sulphuric Acid	5.4	12.9	3.8	75
Natural bituminous sand	5.8	11.5	3.6	80
0.072% Soda ash	7.0	8.7	3.1	100
0.104% Soda ash	8.3	10.1	2.2	100
Bituminous Sand No. 3:				
0.023% Sulphuric Acid	5.3	15.5	16.2	75
Natural bituminous sand	6.3	15.9	2.3	85
0.052% Soda ash	7.1	11.6	1.2	95
0.019% Soda ash	8.1	10.3	2.1	100
0.12% Soda ash	9.1	14.0	3.8	100

bitumen in the bituminous sand is recovered and the bitumen contains only a few per cent of sand. For the three bituminous sands used in the investigation, from one to one and a half pounds of alkali per ton of bituminous sand would be required in actual plant operations to neutralize the acidity in the sand.

The effect of lime in bituminous sand on separation is shown by the data in Table II. It will be noted that in some experiments calcium chloride instead of lime was added to the bituminous sand. But caustic soda was also added and calcium chloride reacts chemically with caustic soda and produces lime. It will also be noted that enough caustic soda was added in all the experiments to make the bituminous sand decidedly alkaline. This was done deliberately to make sure that whatever happened in the experiment was due to the lime and not to the bituminous sand being acid.

The experiments show that some lime can be present in the bituminous sand without causing trouble, for the first experiment in each group gave a good separation. But when the lime present amounts to from five one hundreds to one-tenth of one per cent of the weight of the bituminous sand (one to two pounds in a ton) the separation is ruined. Hardly any bitumen is recovered, and what little is obtained is half sand. Much smaller quantities of lime cause serious decreases in yield and cleanliness of bitumen.

The results from two experiments with each bituminous sand where calcium carbonate was added to the bituminous sand are shown in Table II. The amounts of calcium carbonate added were very much greater than amounts of lime added in the other experiments and yet no serious damage was done to the separation results. From five to fifty times as much calcium carbonate were added and yet the yields of bitumen were good and the bitumen was not sandy.

TABLE II.

Results of tests to show the effect of lime in bituminous sand on its separation by means of hot water.

Preparation of bituminous sand for separation		Composition and yield of bitumen		
Reagents added to bituminous sand	pH	Water content of bitumen %	Sand content of bitumen %	Yield %
Bituminous Sand No. 1:				
0.035% Calcium Chloride + 0.08% Caustic Soda	11.2	9.9	2.6	98
0.10% Calcium Chloride + 0.143% Caustic Soda	11.2	21.4	39.6	5
0.026% Lime + 0.058% Caustic Soda	11.1	9.2	3.1	85
0.065% Lime + 0.058% Caustic Soda	11.2	25.6	41.8	10
0.26% Calcium Carbonate + 0.065% Caustic Soda	9.9	7.8	4.1	93
0.65% Calcium Carbonate + 0.065% Caustic Soda	10.0	7.8	7.3	90
Biutminous Sand No. 2:				
0.057% Calcium Chloride + 0.104% Caustic Soda	11.1	8.2	5.5	98
0.10% Calcium Chloride + 0.114% Caustic Soda	11.1	......	......	0
0.26% Calcium Carbonate + 0.065% Caustic Soda	9.7	18.4	4.8	100
0.65% Calcium Carbonate + 0.052% Caustic Soda	7.1	19.5	5.3	99
Bituminous Sand No. 3:				
0.013% Lime + 0.052% Caustic Soda	11.1	8.0	2.0	93
0.039% Lime + 0.098% Caustic Soda	11.4	......	......	0
3.9% Calcium Carbonate + 0.039% Caustic Soda	9.0	8.9	4.3	93
6.5% Calcium Carbonate + 0.033% Caustic Soda	8.4	9.0	3.3	91
0.13% Lime + 0.30% Soda Ash	11.4	11.8	2.7	99

Obviously, calcium carbonate is not a harmful substance to have present in bituminous sand. And from this fact a very interesting deduction follows. If there was an alkaline chemical which could be used for neutralizing the acid in bituminous sand and which turned calcium compounds into calcium carbonate instead of lime, the danger from lime could be avoided. Soda ash is such a chemical. And the last experiment in the table shows that the deduction is correct. An amount of lime more than sufficient to ruin separation was put into the bituminous sand and then soda ash instead of caustic soda was used to make the bituminous sand alkaline. The separation recovered all the bitumen and, what is more, there was very little sand in it.

The discovery of the secret of bituminous sand separation does not mean that we have just discovered how to separate bituminous sand. We have been able to do that for a long time. Our knowledge could be stated in this way—"We have found it to be true of all the bituminous sand we have worked with that if you do this and this and that it will separate very nicely." Then, at the separation plant in the North, we encountered bituminous sand which did not separate nicely when one did "this and this and that." Now as a result of the work of the past year we can say, "if bituminous sand is made neutral or alkaline by treatment with soda ash, there will be no difficulty in separating it. Failure of bituminous sand to separate is due to acidity and lime." Incidentally, soda ash is cheaper than silicate of soda—the treating reagent which has been used in all past work.

REPORT OF SOIL SURVEYS FOR 1931

By F. A. Wyatt.

During the summer of 1931 three parties were engaged in soil surveys in the following areas:

(1) The party under J. L. Doughty covered the area adjacent to Lac La Biche.

(2) The party under O. R. Younge covered the area from Beaver River north to Cheecham.

(3) The party under A. D. Paul covered the area from Grouard to Peace River.

A summarised statement of the soil classes for the above three areas is shown in the following table:

Soil Class.		Areas (Acres)
2nd class parkland	(A2)	66,680
1st class wooded	(W1)	428,400
2nd class wooded	(W2)	624,580
3rd class wooded	(W3)	3,435,755
Muskeg	(M)	2,801,087
Lakes	(L)	627,448
Eroded	(E)	24,320
Total area		8,008,270

The better soils as shown by the first two classes in the above table are at present practically all taken. Certain parts of the second class wooded soils are likewise settled. It is estimated that there are at least half a million acres in the first three classes shown in the above table which are suitable for immediate settlement.

It will be seen that approximately 35% of the area surveyed during the past year consists of muskeg. The area covered by Younge's party contains about 55% muskeg. In certain parts of this area muskeg constituted as much as 90% of the whole area. The upland soils in such areas consisted of sands or morainal material. In fact, the area covered by Younge's party contains a greater proportion of poor soils than any area surveyed by us to date.

The area covered by Paul's report was the best of the three areas investigated during the summer.

The distribution of the various soil classes, together with more exact locations are shown below under headings for the three different areas surveyed.

(1) The area adjacent to Lac La Biche, tps. 64 to 71 inclusive, rgs. 8 to 18 inclusive. The area is approximately 66 miles long and 48 miles wide and contains 2,027,530 acres classified as follows:

		Acres.
1st class wooded soil	(W1)	91,840
2nd class wooded soil	(W2)	138,120
3rd class wooded soil	(W3)	985,675
Muskeg	(M)	507,767
Lake	(L)	304,128
Total		2,027,530

The majority of the W1 and W2 are occupied or filed upon. Scattered quarters of this soil may still be vacant, but they are comparatively few in number and have not been designated on the map. The major portion of the entire area is classed as W3 soil. Very little settlement has taken place on the W3 soils and the settlement on this area is limited to the quarters adjacent to the W1 and W2 areas. About 23% of the total area is muskeg. Small areas of the W3 soils support a good growth of native grasses and would make good grazing land. Such areas, however, are limited to the burnt over country with the heavier subsoils and to the river bottoms in the sandy areas. Very little grass is found on the sand ridges or in the muskegs. Natural hay meadows are found along the Owl river and the La Biche river. The present area of these can be somewhat increased by clearing and drainage, but in general the settlers will have to be dependent on cultivated crops for most of the winter feed. The W3 lands in general are not recommended for settlement. Extensive areas in certain parts of the W3 class consist of sands.

No difficulty has been experienced in securing adequate supply of water in any part of the area covered by us.

No large areas of commercial timber were found during the summer. However, some excellent stands of young timber were observed. It is thought that in general the unsettled portion of the area has more value as forest and game reserves than as potential agricultural lands.

Good roads connect the larger areas of W1 and W2 soils with Lac La Biche and Plamondon.

(2) The area surveyed by this party is situated in the north central portion of Alberta adjacent to the Alberta-Saskatchewan boundary. It is bounded on the south by the Beaver river (Tp. 63), on the west by the Sand river in Rgs. 7 and 8, on the north by the 22nd baseline (Tp. 84), and on the east by the Alberta-Saskatchewan boundary. The dimensions of the area as above outlined are 132 miles north and south by about 40 miles east and west, comprising almost 3½ million acres.

The classification of the soil within this area is indicated below:

		Acres.
1st class wooded soil	(W1)	72,480
2nd class wooded soil	(W2)	66,080
3rd class wooded soil	(W3)	1,170,180
Muskeg	(M)	1,848,320
Lake	(L)	268,320
Eroded	(E)	24,320
Total		3,449,600

The choicest lands in the entire area are found for a distance of about 5 to 10 miles north of Beaver river and again in the vicinity of Cold Lake. These lands are only about 77,000 acres in extent and are quite largely taken at the present time. The second class wooded soils (66,000 acres) are found to a small extent adjacent to the better lands just mentioned and again along the A. and G.W. near Pickford, Tp. 80. In the latter area there are probably about 2 townships which could be settled.

The remainder of this area consists largely of muskegs and third class wooded soils, each group of which contains between one and two million acres. There are more muskegs in this area than we have encountered up to the present time. In fact, it is estimated that as high as 90% is muskeg. The third class wooded soil which, in general, occurs adjacent to the larger muskeg systems is of low quality. The same type of low quality land likewise occurs in irregular areas distributed throughout the muskeg. The higher lands consist chiefly of sand ridges, together with some moraines. It is not definitely known to what extent the underlying material in the muskeg areas is sand, but in most instances where we were able to inspect this material it was found to be sand. From our traverses this area contains the most extensive sand areas that we have yet found in the Province. It seems to have little hope of providing suitable lands for settlement.

The timber covering consists very largely of jackpine confined to the ridges and spruce to some of the muskegs. In practically no instance did we see merchantable timber in any great quantities. In some areas the trees were large enough for tie timber. Grass over the entire area is very scarce and limited only to small areas adjacent to the main streams or to some of the lakes. In many places there was not enough feed for the pack outfit. From our observations game was rather scarce in the surveyed area. The only indications of the larger game, such as moose, deer or bear, were found along the larger streams and in those locations only at rare intervals. Ducks and spruce hens were found in certain areas.

It is doubtful, in our opinion, if the area in general would ever become valuable as a source of merchantable timber. We are confident, however, that the greater part of the area should be withheld from settlement.

Travel is extremely difficult across this area, especially north of Township 66, which in general coincides with the increase in muskegs. Trails of any kind are unknown except those which we have indicated on the map, and they are impassable during the summer months, except to pack outfits.

Considerable difficulty was experienced in traversing this country even with a pack train. The party, which consisted of three men and ten horses, left Cold Lake on June 29th. The route proceeded northward to Primrose lake, up along the Shaver river and across the higher land to Nisbit lake, and then along the Winefred and Christina rivers to the intersection of the Cheecham-Peter Pond sleigh road and then westward to Cheecham. This point was reached on August 10th, the 42nd day of travel. The distance in an air line is about 130 miles, but possibly the party travelled more than 200 miles. Owing to the scarcity of feed and the heavy travel, due to the large amount of muskegs, the horses failed rapidly. Two were drowned and one snagged.

(3) From Grouard to Peace River, Tp. 75 to 84 inclusive, and from the Smoky river on the west to Rg. 11 on the east.

The area contains about 2½ million acres with the various soil classes shown in the following table:

Soil Class.		Areas (Acres)
2nd class parkland	(A2)	66,680
1st class wooded	(W1)	264,080
2nd class wooded	(W2)	420,380
3rd class wooded	(W3)	1,280,000
Muskeg	(M)	445,000
Lakes	(L)	55,000
Total		2,531,140

The A2 lands are all taken and the W1 lands are practically all taken. Possibly a little less than 50% of the W2 lands remain to be settled. This would mean something less than a ¼ million acres. There is much less muskeg in this area than was encountered in either of the two previous areas. There is likewise a smaller proportion of lake areas, and in some sections difficulty is encountered in finding adequate water supply. Some of the areas having soils suitable for settlement contain extremely heavy timber and the cost of clearing would be rather expensive.

The better settled areas are well supplied with roads and fairly well supplied with railroads. A few small areas of merchantable timber were found on this sheet. The poor soil areas found in the W3 class would provide excellent forest and game reserves. In certain parts of the surveyed area game was plentiful.

One area consisting of about a township in extent is a natural park and would furnish an excellent recreation ground for the people of the surveyed area. It is only about two hours' drive from Peace River by car. We have outlined it on the map, and suggested that it be set aside for this purpose. It consists of very poor soil covered with jackpine, and has a stream flowing through the area.

NATURAL GAS RESEARCH

By E. H. Boomer.

During the period under review this project has been continued along three lines: hydrogenation, water gas reactions, and pyrolysis. The work on the hydrogenation of McMurray bitumen in the 1800 cc. batch autoclave has been brought to completion. The work on the hydrogenation of Alberta coals has also ceased for the time being with the completion of experiments on the coals of the 1930 survey. Recent attention has been confined to test runs on a 4000 cc. continuous autoclave, which will operate initially on McMurray bitumen and later on coal. The reactions of water gas and mixtures of carbon dioxide and hydrogen over catalysts at high temperatures and pressures are still under investigation. This work will be continued until such time as the equipment for the investigation of liquid-gas equilibria in hydrocarbon systems at high pressures is available. The laboratory work on the pyrolysis of Alberta natural gas progressed to the stage that large scale experiments were deemed advisable. A new laboratory has been set up and equipped in the Provincial Institute of Technology and Arts at Calgary for the investigation of the process under semi-plant conditions.

Until May, 1931, three assistants were employed, and at that time two additional men were appointed. At the end of September two of the original assistants departed. In October an additional man was appointed to the Calgary Laboratory. At present, J. Edwards is operating the hydrogenation equipment, G. H. Argue is carrying on the water gas investigation, and P. E. Gishler, assisted by A. T. Baker, is in the Calgary Laboratory.

Financial grants have been made by the Research Council of Alberta and the National Research Council of Canada, the former body contributing approximately two-thirds of the total cost.

Hydrogenation.

Bitumen.

These experiments proceeded along the lines indicated by previous work given in the Eleventh Annual Report. The beneficial effect of increased hydrogen concentration was investigated fully and gave much improved results. The bitumen charges amount to only 400 gr. and left a gas phase of 1400 ccm. in the autoclave. It was found that the limiting quantity of hydrogen could be added under these circumstances in one treatment. Experiments were carried out at 400°C, 425°C, and 450°C, and the effect of various catalysts was examined. Coke production is zero at 400°C and 425°C and quite small at 450°C. The catalysts speeded up the reaction to some extent, but had no apparent effect on oil quality.

Further investigation on this point is planned in view of the conflicting result reported elsewhere. A temperature in the neighborhood of 425°C appears most favorable under the conditions of batch operation. Approximately 85% of the bitumen may be recovered as oil, 50% of which distills below 300°C. The remainder appears as gas and as experimental loss. The oil quality as determined by physical tests is superior to that produced under conditions of lower hydrogen concentrations.

To illustrate clearly the beneficial effect of a generous supply the absolute relative rates of hydrogen absorption on three experiments may be quoted. These experiments had volume ratios of bitumen to hydrogen of 1:1, 1:1.5 and 1:3, and the absolute rates of hydrogen absorption during the period of most active reaction were in the ratio 0.4:0.3:0.1. A series of experiments was carried out using different hydrogen concentrations with the same quantities of bitumen and initial pressure of gas by dilution of the hydrogen with natural gas. Less than 65% hydrogen in the gas gave rise to a large decrease in velocity of reaction together with an increase in coke production as a consequence.

The final work on bitumen consisted in the hydrogenation of the residual oils and pitches resulting from the distillation of previously treated bitumen. The success of a continuous process for the hydrogenation of bitumen will depend on the reduction of all the bitumen to oil as much as an adequate supply of hydrogen. Preliminary to the operation of a continuous process, it must be determined if the resistant high boiling compounds of the bitumen can be hydrogenated. They are contained in the residual oils previously mentioned, and include besides stable hydrocarbons of high molecular weight, complexes termed asphaltenes, tar acids and tar bases.

The materials used varied from a fluid oil of initial boiling point 225°C to a brittle pitch melting above 200°C. The asphalt content determined by the A.S.T.M. method varied from 25% in the fluid oils to over 99% in the brittle pitch. The ease of hydrogenation varied inversely with increasing boiling point of the material. The oils and soft pitches could be hydrogenated readily with or without added catalysts. They were not as reactive as the original bitumen. With the hard and brittle pitches no action occurred below 450°C or in the absence of catalysts. The pure asphalt pitches required temperatures as high as 500°C and a destructive catalyst like $AlCl_3$ before decomposition and hydrogenation occurred. A portion of these materials, presumably present in the original bitumen, was found to be extraordinary stable. This material occurred in larger amounts in the harder pitches and is apparently asphaltic in nature. Decomposition must be brought about before reaction with hydrogen can occur, and consequently coke formation is large. That a deep-seated change occurs was evident in the large water and ammonia production which did not occur elsewhere. Apparently the resistant residue is a compound containing oxygen and nitrogen and cannot be directly hydrogenated. The 90% asphalt pitch seemed to be largely this resistant material, and on destructive hydrogenation yielded 25% coke, 53%

oil and the rest gas. The coke was in a finely divided form offering no mechanical difficulties.

Summarizing the results as a whole, they show that 75% of the bitumen may be reduced to gasoline and light oils, 10% to gas and 15% to resistant asphaltic compounds. The percentage asphaltic compounds is remarkably constant in all the experiments but one. Here the asphalts were reduced to 10% of the original bitumen, and a further study of other experiments of the same nature will be carried out.

Coal.

The following section deals briefly with the hydrogenation of Alberta coals in the 1800 cc. batch autoclave. The preliminary work leading to the best conditions is described, together with the results from a series of typical Alberta coals.

The mechanical and chemical properties of coal are very different from those of bitumen and the same experimental methods cannot be applied to both. Early experiments in another autoclave, as well as the more recent work, showed these differences in a striking manner. The coal cannot be satisfactorily treated in its dry form and must be suspended in some favorable liquid medium. The various media examined were in the order of their effectiveness, residual oils from hydrogenated bitumen, bitumen, phenol, a medicinal paraffin oil (boiling range 300°C to 400°C) and tetrahydronapthalene.

The last substance named, tetrahydronapthalene, commonly and hereafter termed tetralin, proved of considerable interest for a variety of reasons, chief of which was its great superiority to any other medium used. Tetralin is easily dehydrogenated to napthalene, and just as easily hydrogenated to decahydronapthalene under the conditions of the experiments. These reactions occurred during the hydrogenation of coal in a tetralin medium, and all three substances could be recovered. Napthalene was shown to be as effective as tetralin, and presumably decahydronapthalene would be equally effective. Tetralin has the true properties of an ideal hydrogen carrier, and as such plays the role of an exceedingly active catalyst besides being a good wetting agent and solvent of coal.

Three coals of the 1929 Coal Survey were used in the preliminary work. One coal from the McLeod River Collieries was classed as sub-bituminous, one from Pincher Creek was bituminous, and the last from Drumheller was a lignite. The preparatory treatment of the coals consisted of drying at 125°C under a vacuum, grinding to better than 100 mesh and incorporation with the catalyst and suspension medium.

The properties of the medium controlled largely the rate and extent of hydrogenation. Of the media used, bitumen and phenol may be classed together as equally effective and superior to the residual oils from hydrogenated bitumen. Phenol has the practical disadvantage of being a solid and yielding a solid mass after the experiment. Liquid petrolatum was definitely superior to the above substances, and was most effective at a temperature such as 425°C. Higher temperatures necessary with the other media, led to cracking of the petrolatum and large coke and gas yields.

Tetralin was much superior to petrolatum and gave higher oil yields and less gas. The rate of reaction was rapid and little affected by catalysts. The conversion of coal to oil was between 70% and 80% compared to 40% to 50% for petrolatum. Tetralin alone was found to be an able hydrogenating agent being reduced to napthalene in the process. Moreover, napthalene with hydrogen was as effective as tetralin and hydrogen. The napthalene was obviously reduced to tetralin in the process, as tetralin was recovered among the products, and the hydrogen consumption was very large. It was interesting to find that little hydrogen was liberated in the reduction of coal by tetralin alone. The transfer of hydrogen from tetralin to coal was remarkably efficient, and gives tetralin a unique position of high efficiency among hydrogen carriers.

The gas produced in these experiments contained large amounts of carbon dioxide, and water was found in the oil. These are produced, in part at least, by the reduction of oxygen containing groups in the coal and require considerable hydrogen. This hydrogen may be considered a complete loss, and an experiment was carried out to see if it could be avoided. Water gas was used in place of hydrogen, and it was found that the carbon monoxide reduced a large part of these oxygen groups. Hydrogen was also absorbed by the coal, and it is suggested that a commercial process could employ cheap water gas in a preliminary reduction.

From these preliminary experiments, standard procedures using petrolatum and tetralin were devised. Charges of 400 gr. were used; made of one part coal and one part petrolatum in the first case and four parts coal to three parts tetralin in the second. Molybdic oxide to the extent of 5% of the charge was added as catalyst in each case. The operating temperature with petrolatum was 425°C and with tetralin was 450°C. An initial pressure, cold, of 1,000 lbs. of hydrogen was always used, and two treatments of four hours each applied. The available hydrogen in each treatment was approximately 4 gr. per 100 gr. of coal.

These two procedures were applied in turn to each of 13 representative Alberta coals of graded rank. The complete analyses of these coals are shown on page 17 of the Eleventh Annual Report of the Research Council of Alberta (1930).

They comprised one anthracite to semi-anthracite, one semi-anthracite to semi-bituminous, three bituminous, two sub-bituminous, and six domestic coals. Each coal was dried at 125°C in a vacuum and samples taken for analysis before incorporation with the suspending medium and catalyst. The oils produced were examined for physical properties and distillation range. No chemical properties have been determined as yet, but the work is under way. It may be said that the oils have a high content of aromatics as indicated by their solubility in 98% sulphuric acid. The experimental details have already been submitted in the form of tables and notes.

For the present report, it will suffice to give the essential data regarding the results as in Table I. The results are chiefly of comparative value in that they show the relative value of each coal as a raw material for a hydrogenation process. They do not give

TABLE I.

Conversion of Coal. Yields on the basis of dry, ash-free coal.

Medium	Petrolatum				Tetralin			
	Oil + gas	Water	Total	Gas production	Oil + gas	Water	Total	Gas production
Coal	%	%	%	%	%	%	%	%
A	8.0	0.0	8.0	12.2	12.8	0.0	12.8	12.0
B	10.1	0.0	10.1	12.7	35.0	0.0	35.0	12.7
C	44.2	1.0	45.2	20.6	73.7	0.0	73.7	16.8
D	*44.2	0.0	44.2	11.8	86.0	0.0	86.0	17.1
E	51.3	2.9	54.2	17.8	85.8	1.0	86.8	15.7
F	54.0	2.5	56.5	18.3	92.8	1.4	94.2	19.2
G	56.2	6.2	62.4	20.1	80.8	10.2	91.0	18.5
H	61.8	5.0	66.8	22.9	81.6	7.7	89.3	21.8
J	63.2	4.4	67.6	16.8	91.0	5.0	96.0	24.6
K	*65.0	3.6	68.6	23.9	86.4	9.4	95.8	22.6
L	*46.3	0.5	46.8	38.6	84.4	7.1	91.5	20.3
M	58.9	2.5	61.4	19.8	90.4	5.9	96.3	20.8
N	74.9	5.6	80.5	21.6	88.2	7.7	95.9	22.4

the absolute yields that could be expected in a commercial continuous process. A higher temperature could be used in a continuous process, and the rate and yields would be generally increased as a consequence. In addition it should be pointed out that the best experimental conditions for higher conversion of each coal have not been determined. The conditions used were the same for each coal and the best for the domestic grades only.

Referring to Table I, the column entitled, gas yield, is ambiguous in that it represents the gas from both the coal and the medium. It is not possible to determine what part is due to the coal alone. In view of the great stability of tetralin, it may be assumed that the gas produced is largely due to the coal. On the other hand, petrolatum is nearly as unstable as the coal itself and no doubt a considerable fraction of the gas produced arises from the decomposition of the petrolatum. In addition it should be pointed out that the solid residue with petrolatum includes coke formed by its decomposition as well as the solid coal residue. In the case of tetralin, the solid residue will be practically all remains of the coal. The high solid residues in the petrolatum experiments give a false impression of the effectiveness of petrolatum as a coal medium. This point is important, as the oil and gas yields have been calculated on the basis of the solid recovered.

Tetralin is definitely a much superior medium as judged by coke and gas formation, conversion to oil and speed of reaction. Its use in a commercial process is possible, but hardly probable, as the process could operate well on a cheaper residual oil. Tetralin is of great interest, however, as an example of a hydrogen carrier of remarkable efficiency. It is much superior to any catalyst used in this respect. Its powerful action is well illustrated by the larger quantities of water produced when compared to petrolatum. By analogy to bitumen, these oxygen compounds may be expected to be very stable and reduction to water difficult. The use of tetralin is of particular interest and of possible applicability in Alberta in view of results of the pyrolysis of natural gas to be reported later. The aromatic tar produced in pyrolysis is very largely napthalene and related compounds, and as such would serve as a cheap source of tetralin and similar compounds.

Regarding the sequence of the coals and its relation to hydrogenation with successively younger coals the amount of hydrogen absorbed, the rate of absorption and the conversions, increase regularly. Opposed to these beneficial results is the greater pressure development, gas production and water production, in the younger coals. Taking into account the gas production and water production, there is little difference in oil production between bituminous, sub-bituminous and domestic coals which include coals G to H. A definite but slight progression occurs in the direction of the younger coals. The anthracite coals, however, are markedly different as regards yields, and show a sudden increase in resistance to hydrogenation as compared to the bituminous coals. No decision in favour of either bituminous coals or domestic coals is possible. Against the very high reduction to liquid and gas with domestic coal must be placed the excessive gas and water production which are not so unfavourable with bituminous coals. Moreover, in a continuous process, there is little doubt that the solid residue with bituminous coals would be materially reduced. The gasoline production obtained by distillation of the oils produced was of much the same order as found with bitumen. It varies from 20% to 30% of the added coal in the range bituminous-domestic.

To determine the possibilities of a continuous process, the residual oils after distillation of the product of both the petrolatum and tetralin series were hydrogenated. They were more resistant than McMurray bitumen, and resembled in many respects the residual oils from bitumen.

They can be hydrogenated at 450°C without much difficulty, however, and are readily reduced upon the addition of some tetralin.

The aromatic tar found as a product of the pyrolysis of natural gas has been hydrogenated at 425°C and found to produce in a single standard treatment over 20% aromatic gasoline. The residual oil is largely tetralin and more complex hydrogenated napthenes. The original tar and also the hydrogenated tar were used as media for the suspension of coal. The tar, and particularly when hydrogenated, serves admirably as a suspension medium comparing very favourably with pure tetralin itself. This result removes to a large extent the objections to the use of tetralin on account of cost, as the aromatic tar that may serve equally as well is a by-product of the pyrolysis process.

Experiments using tetralin as an accelerator in the hydrogenation of McMurray bitumen gave an unexpected result. As far as the experiments showed, no great advantage lay in its use as far as yields were concerned. The rate of hydrogen absorption was very greatly increased, however.

Preliminary experiments in the large continuous autoclave with McMurray bitumen show good promise. A catalyst appears to be essential, molybdic oxide being used. The operating procedure consists in taking off the light oil as formed as a pressure distillate and pumping into the autoclave an equivalent amount of bitumen. The most satisfactory experiment of the preliminary work was of 12 hours' duration, and resulted in the formation of only 7% of coke. The overall production of gasoline was 40% and the experiment could have been extended to several days with a consequent cumulative increase in gasoline production. The operating procedure and mechanism will shortly be perfected and true continuous tests will be possible.

Water Gas Reactions.

This division has been concerned chiefly with the preparation of catalysts and the determination of the reactions of water gas and mixtures of carbon dioxide and hydrogen over these catalysts. The temperature range was 200°C to 500°C at pressures from 1,000 to 3,000 lbs. per sq. inch. Two sets of equipment have been in use and an enormous amount of data has been secured. It is, however, of little practical value inasmuch as the ethyl alcohol synthesis sought has not been found. Certain work reported elsewhere gave experimental details of the production of ethyl alcohol in small amounts from water gas over complex catalysts. Catalysts of similar properties had been previously examined here and identical catalysts have been used since without any positive results.

The work has a distinct scientific value in extending and confirming much of the knowledge in this field. The nature and course of the many possible reactions have been discovered in some cases, and in particular, the mechanism of the formation of methyl alcohol from carbon dioxide and hydrogen has been elucidated in part. Before any methyl alcohol formation begins, it appears that there is a primary reaction consisting of the reduction of carbon dioxide to carbon monoxide and water. The carbon monoxide then reacts with hydrogen in the usual manner to give methyl alcohol. It might also be mentioned that the existence of a copper carbonyl has been indicated which is stable only at high pressures in a reducing atmosphere. This result is of distinct scientific value in leading to a fundamental mechanism for the action of the catalysts in promoting reactions in water gas and like mixtures. Over certain classes of catalysts acidic liquids have been obtained. These acids are saturated fatty acids and predominatingly acetic. They occur over catalysts that do not promote the formation of methanol in more than traces. The phenomenon has been noticed elsewhere, and is attributed to the direct union of carbon monoxide with methyl alcohol to give acetic acid. It has been predicted that this method will be of value in the preparation of fatty acids which together with synthetic alcohols will yield esters.

The direct synthesis of ethyl alcohol does not appear probable, and an indirect synthesis through methyl alcohol is a remote possibility in view of the much greater ease of formation of higher alcohols and oils. Ethyl alcohol differs radically from methyl alcohol in this regard. The catalysts useful in the decomposition of methyl alcohol to carbon monoxide and hydrogen are generally efficient in promoting its synthesis. In the case of ethyl alcohol this is not true, and the most efficient catalysts for its decomposition promote the formation of water, oils and acids from water gas and similar mixtures.

In view of the efficiency of tetralin as an hydrogenating medium for reduction of coal, a number of experiments were carried out in this section to determine its hydrogenating powers in a more general way. As a reaction medium for water gas and for carbon dioxide and hydrogen mixtures, it was only slightly active. As an hydrogenating medium for the reduction of cellulose and of wood to liquids it was found to be extremely efficient. Practically complete reduction of cellulose and of wood to water, oils and gas is rapidly effected. Other work designed to determine more fully the powers of tetralin is under way. It should be pointed out that an examination of the properties of tetralin may be of great value. Its preparation from napthalene is a commercial process and the pyrolysis of natural gas yields considerable quantities of napthalene as a by-product possessing at present little market in Western Canada.

PYROLYSIS.

During the period under review, the laboratory work in this division was brought to a conclusion in the University laboratory. The work dealt largely with questions of technique and reaction mechanisms since it had previously been shown that commercial possibilities lay in the process. In addition, experiments were completed covering the recirculation of gas through the reaction tube.

One of the subjects investigated was the relation between the true yield of light oil and the yield as given by the increase in weight of the charcoal absorbers. It has been shown definitely that charcoal absorbs gaseous as well as vapour constituents from the gas mixture passed over it. The increase in weight of the charcoal includes these gaseous constituents and they may, in experiments of short duration, be an appreciable fraction of the total weight increase. An error would be introduced into the determination of yields, by this method. A series of experiments showed that the unsaturated gases and others that were caught in the charcoal were absorbed by only a small, very active, part of the charcoal. After this partial saturation was complete, no further absorption of gases occurred. The benzene and toluene vapours were absorbed on the remaining surface of the charcoal readily and completely until about 20% by weight of the charcoal was taken up. Consequently, weight increases subsequent to the initial increase due to gaseous absorption could be used as a measure of yield. It was obvious, of course, that the gas passed during the initial period was disregarded, and gas analyses showed it to be deficient in unsaturated hydrocarbons. Previous to this development, extended experiments were necessary in order that the weight increase should correspond to the amount of oil recovered by steam distillation. It was necessary to saturate the charcoal with the light oil in order that the absorbed gases be displaced. With the new technique, experiments could be performed rapidly and several different sets of conditions explored in one day. The quantity of oil produced in each individual run was very small, but could be accurately determined by the increase in weight of the charcoal. The total recoverable oil was always checked with the total of the individual weight increases in order to reveal any experimental faults during the run.

A second point carefully investigated was the true gas temperature in the reaction tube. The difficulties in measuring the true temperature of a gas flowing in a heated tube are well known and have been discussed before in connection with this work. It appears to be almost impossible under the conditions used to obtain a complete description of the temperature throughout the gas in the tube. A method was developed that gave the true gas temperature at one point in the reaction tube, and this point was not at the region of maximum temperature. It was found in the range of wall temperatures used, namely, 900 to 1100°C, that the true gas temperature of a thermocouple in the flowing gas lay between the two and nearer to the wall temperature. The temperature conditions in the reaction tube, although unknown, are always reproducible and of comparative value. The value of the work was in demonstrating that the true gas temperature in the reaction zone was not greatly different from the indicated temperature. Considerable interest attaches to the work in Calgary, using larger tubes, in regard to this matter, and no doubt the indicated temperature found to be the most efficient in small tubes will not apply to the larger tubes.

Except in one respect, no new work on the identification of the liquid product has been carried out. Among the liquid products of the reaction there occurred a low boiling hydrocarbon in small amounts. This substance has not been identified beyond classifying it as an unsaturated aliphatic hydrocarbon of boiling point around 40°C. It is hoped to obtain sufficient quantity from the larger scale work now in progress to identify it completely.

In regard to the liquid products it may be of interest to refer to some work done elsewhere on the light oil obtained in the pyrolysis of stabilizer gas. This oil is very similar to the light oil produced here, and when blended with a straight run gasoline gave a motor fuel of high anti-knock value much superior to a straight benzene blend. This is to be expected from the presence of toluene and xylene in the light oil, which are better anti-knock substances than benzene.

One further investigation carried out dealt with the effect of hydrogen sulphide on the pyrolysis reaction. No untoward effects had ever been noticed with the Turner Valley gas, but its sulphur content was quite small by the time it reached here. Hydrogen sulphide was added to Viking gas in amounts ranging from 0.5 to over 10.0% before pyrolysis. The yields and the products did not seem to be altered except in odor, which was due to dissolved hydrogen sulphide at concentrations below 5%. Above 5%, amounts of carbon disulphide were formed and collected with the benzene. It is probable that carbon bisulphide was also present at the lower concentrations, but only in small traces.

A series of circulation experiments was carried out on Viking and on Turner Valley gas. In this work, the pyrolysed gas was again sent through the reaction tube and the process repeated three times, giving a total of four passages to the gas. As the hydrogen content of the gas increased, the conversion of hydrocarbons to oil decreased and the temperature required for appreciable reaction increased. The efficiency referred to the oil production in terms of methane decomposed increased with hydrogen concentration to a high figure. The production of tar relative to the oil production decreased with the increasing hydrogen concentration. As a consequence a larger proportion of light oil could be obtained in this step-wise process. The behaviour of the reaction in these experiments threw much light on the mechanism and has permitted the development of a rational theory.

For a single heat treatment the maximum yield of liquid products from Viking gas is in the neighborhood of 0.43 gallons per 1,000 cu. ft. Of this yield, 0.22 gallons were light oil, and 0.21 gallons were tar. Turner Valley gas yielded 0.66 gallons per 1,000 cu. ft., of which 0.36 gallons were oil and 0.30 gallons tar. The light oil production could be increased above these quantities by as much as 20%, but at the same time the tar production decreases to a greater extent.

With four treatments of the sample of Viking gas, a total yield of 0.92 gallons was obtained, of which 0.47 gallons were light oil. With the same procedure, Turner Valley gas produced 1.4 gallons per 1,000 cu, ft., of which 0.78 gallons were light oil.

The amount of gaseous hydrocarbons decomposed in a single treatment under optimum conditions of oil yield was approximately 30%. Of this portion decomposed, 45 to 50% resulted in the production of aromatic hydrocarbons, about 5% as unsaturated hydrocarbons, and the remainder as carbon and hydrogen. This free carbon was not deposited in the reaction tube to any extent after the initial stages of the experiment, but appeared as suspended carbon, largely colloidal, in the tar and as coke near the exit end of the reaction tube.

A laboratory, a gas fired pyrolysis furnace and accessory equipment, such as controlling instruments and a charcoal absorption unit, have been set up in the Provincial Institute of Technology and Art at Calgary to investigate the possibilities of large scale work. Considerable delay was experienced in obtaining the required equipment, and as a result the assembly was only completed in October, some two months late.

The gas used is taken from the Calgary mains at 35 lbs. pressure and is a composite Turney Valley gas from which most of the hydrogen sulphide and a part of the organic sulphur compounds have been removed. Quartz reaction tubes, 1.5 in. in diameter have been chosen, and the furnace is such that 14 are heated over a 19 in. length. The furnace includes a pre-heater in which the flue gas raises the temperature of the gas entering the pyrolysis tubes to 550°C. No decomposition occurs at this temperature. The gas flow and the furnace temperature are automatically controlled and recorded. The temperatures at various critical points may be found when desired by manual readings. As a check on the flow controller readings, the total gas consumption in the pyrolyser is determined on a dry meter and the exit gas to the waste line is also measured on a similar meter. An accurate wet test station meter gives the total consumption of gas in the laboratory, and a small dry meter will be used to determine that used for fuel.

The pyrolysed gas passes first through a condenser to remove part of the tar and cool the gas. Following this is an electrical precipitator to remove the tar fog, and after this the gas goes directly to the charcoal absorbers and then to waste. Provision has been made for the utilization of the waste gas as fuel. Steam required for the recovery of oil from the charcoal is provided by an obsolete type of steam tractor set up just outside the laboratory. Its installation cost was nothing, and to obtain steam from the Institute power plant required the construction of a long pipe line and an accounting for any steam used.

Since the installation was completed, attention has been paid to the satisfactory operation of the various units. The furnace was designed to ensure uniform temperature distribution over all the tubes, and also to give equal flow of gas through each tube. Perfect results were not obtained, but only minor adjustments will be required to bring the conditions within the required limits. In an endeavour to reduce costs, a regulation electrical precipitator was not constructed, but a modification using a simple induction coil has been installed. The relative costs are in the ratio of ten to one and made the attempt worth while. In spite of two years' experience with laboratory set-ups, a great deal of trouble was experienced and the knowledge gained in the laboratory was of little value. Recently, after three weeks effort, a satisfactory performance was obtained. The delay was not unreasonable considering the difference in costs and that the same laboratory coil had to handle about 800 times as much gas per hour.

All the runs to date have been test runs for the purpose of elucidating one point or another of operating technique. No data on production for long periods of time are available, but it appears as though operations will be satisfactory. Regular production will commence shortly. With a few minor alterations, particularly with regard to the preheating of the natural gas, the plant will exceed its designed capacity by at least 50%.

The oils and tar produced are very similar in nature to those produced in the laboratory work. The light oil to tar ratio is definitely greater in every test run made.

Preliminary laboratory scale experiments have been commenced on the pyrolysis of stabilizer gas. Stabilizer gas is the gas lost by weathering crude naphtha and contains largely the gaseous hydrocarbons above methane and ethane in the series. The yields of liquids are very high, over 2 gallons of light oil and 1 gallon of tar per 1,000 feet are readily obtained. The exit gas is of great interest in containing a volume of ethylene equal to 50% or more of the stabilizer gas used. This gas offers great possibilities as a recycle gas for the production of more oil or as a source of ethylene itself. The pyrolysis of ethylene may be controlled to give various products, a procedure that is not possible with the original stabilizer gas. Moreover, ethylene is the starting point for other compounds, chief of which may be mentioned ethyl alcohol and ethylene glycol.

This project of the pyrolysis of natural gas is a joint work with the National Research Council Laboratories in Ottawa. The work in Ottawa is dealing with the production of ethylene as a primary product of natural gas, whereas the work here deals with the production of liquid hydrocarbons as a primary product. The most economic procedure is still in doubt, and depends not only on the nature and amount of gas available, but the market for the products available.

The assistance of the staff of the Technical Institute has been at the disposal of the writer and Mr. Gishler at all times, and is gratefully acknowledged. The use of their machine shop and lately of the labour of the students has been frequently granted. Power, light and compressed air have been made available without charge. Thanks are due to the Canadian Western Gas, Light, Heat and Power Co., who have furnished the necessary gas meters free for the time being, and who also installed and supplied without charge the pipe line to the laboratory, a reducing regulator, piping to the steam generator, and the burner and fittings in the steam generator. The Royalite Oil Co. have kindly supplied crude naphtha from the separators in the Turney Valley as a source of stabilizer gas for experiments on a laboratory scale and will replenish the supply when required.

In conclusion, it may be pointed out that detailed reports of each section of this project to the end of April, 1931, are in the University Library in the form of theses presented by the assistants concerned, A. W. Saddington, H. E. Morris and P. E. Gishler.

LIST OF PUBLICATIONS

OF

RESEARCH COUNCIL OF ALBERTA.

EDMONTON, ALBERTA

ANNUAL REPORTS OF COUNCIL

No. 3 (for the calendar year 1920); pp. 36. **Price 5 cents.**

No. 5 (for the calendar year 1921); pp. 86. **(Out of print.)**

No. 8 (for the calendar year 1922); pp. 64. **Price 35 cents.**

No. 10 (for the calendar year 1923) with 4-color map of Alberta coal areas; pp. 76. **Price 50 cents.** Map No. 6 only, **15 cents.**

No. 12 (for the calendar year 1924); pp. 66. **Price 35 cents.**

No. 16 (for the calendar year 1925); pp. 65. **Price 35 cents.**

No. 20 (for the calendar year 1926); pp. 53. **Price 25 cents.**

No. 22 (for the calendar year 1927); pp. 49. **Price 25 cents.**

No. 24 (for the calendar year 1928); pp. 53. **Price 35 cents.**

No. 25 (for the calendar year 1929); pp. 65. **Price 35 cents.**

No. 26 (for the calendar year 1930); pp. 76. **Price 35 cents.**

No. 27 (for the calendar year 1931); pp. 53. **Price 35 cents.** Reviews items of investigation carried out under the auspices of the Council during 1931. Continuation of a detailed examination of 13 typical coals from the south of the Province and commencement of a similar examination of 17 typical coals occurring further north. Improvement in method for the standardisation of air drying of coal and a new method for determining the moisture holding character of coal. Geological investigations on occurrence of iron ore at Burmis, building stone at Cochrane and gypsum deposits in the vicinity of Jasper Park. Results of 3 field survey parties on soil surveys in areas north of Edmonton. Further details on the separation process for the extraction of bitumen from the bituminous sands. The operation of a semi-commercial natural gas pyrolysis laboratory at Calgary for the production of benzine and other derivatives from Turner Valley natural gas.

REPORTS—FUELS

No. 10A (1923); COMBUSTION OF COAL FOR THE GENERATION OF POWER, by C. A. Robb. **(Out of print.)**

No. 14 (1925); pp. 64. ANALYSES OF ALBERTA COALS, with 18 maps and 2 charts. By E. Stansfield, R. T. Hollies, and W. P. Campbell. **Price 25 cents.**

REPORTS—ROAD MATERIALS

No. 18. THE BITUMINOUS SANDS OF ALBERTA, by K. A. Clark and S. M. Blair.

Part I—Occurrence, pp. 74. **Price 25 cents.**
Part II—Separation, pp. 36. **Price 25 cents.**
Part III—Utilization, pp. 33. **Price 25 cents.**

REPORTS—SOIL SURVEY DIVISION

No. 23 (1930); PRELIMINARY SOIL SURVEY ADJACENT TO THE PEACE RIVER, ALBERTA, WEST OF DUNVEGAN, by F. A. Wyatt and O. R. Younge; pp. 33 and colored map. Scale 1 inch to 4 miles. **Price 50 cents.**

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REPORTS—GEOLOGICAL SURVEY DIVISION

By Dr. J. A. Allan, Professor of Geology, University of Alberta.

No. 1 (1919); pp. 104—A summary of information with regard to the mineral resources of Alberta.

No. 2 (1920); pp. 138+14. Supplements the information contained in Report No. 1.

No. 4 (1921); GEOLOGY OF THE DRUMHELLER COAL FIELD, ALBERTA; pp. 72, and 6-color map (Serial No. 1). **Price $1.00.**

No. 6 (1922, Part I); GEOLOGY OF THE SAUNDERS CREEK AND NORDEGG COAL BASINS, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 76, and 2-color map (Serial No. 2). **(Out of print.)**

No. 7 (1922, Part II); AN OCCURRENCE OF IRON ON THE NORTH SHORE OF LAKE ATHABASKA, by J. A. Allan and A. E. Cameron; pp. 40; two maps (Serial Nos. 3 and 4). **(Out of print.)**

No. 9 (1923); GEOLOGY ALONG BLACKSTONE, BRAZEAU AND PEMBINA RIVERS IN THE FOOTHILLS BELT, ALBERTA, by J. A. Allan and R. L. Rutherford; pp. 48, and 6-color map (Serial No. 5). Continuation of the field work in the area described in Report No. 6. **(Out of print.)**

No. 11 (1924); GEOLOGY OF THE FOOTHILLS BELT BETWEEN McLEOD AND ATHABASKA RIVERS, ALBERTA, by R. L. Rutherford; pp. 61, and 8-color map (Serial No. 7). One inch to two miles. Continuation of the area described in Report No. 9. **Price 75 cents.**

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Map No. 10 (1925); GEOLOGICAL MAP OF ALBERTA, by J. A. Allan. In 14 colors. Scale one inch to 25 miles.

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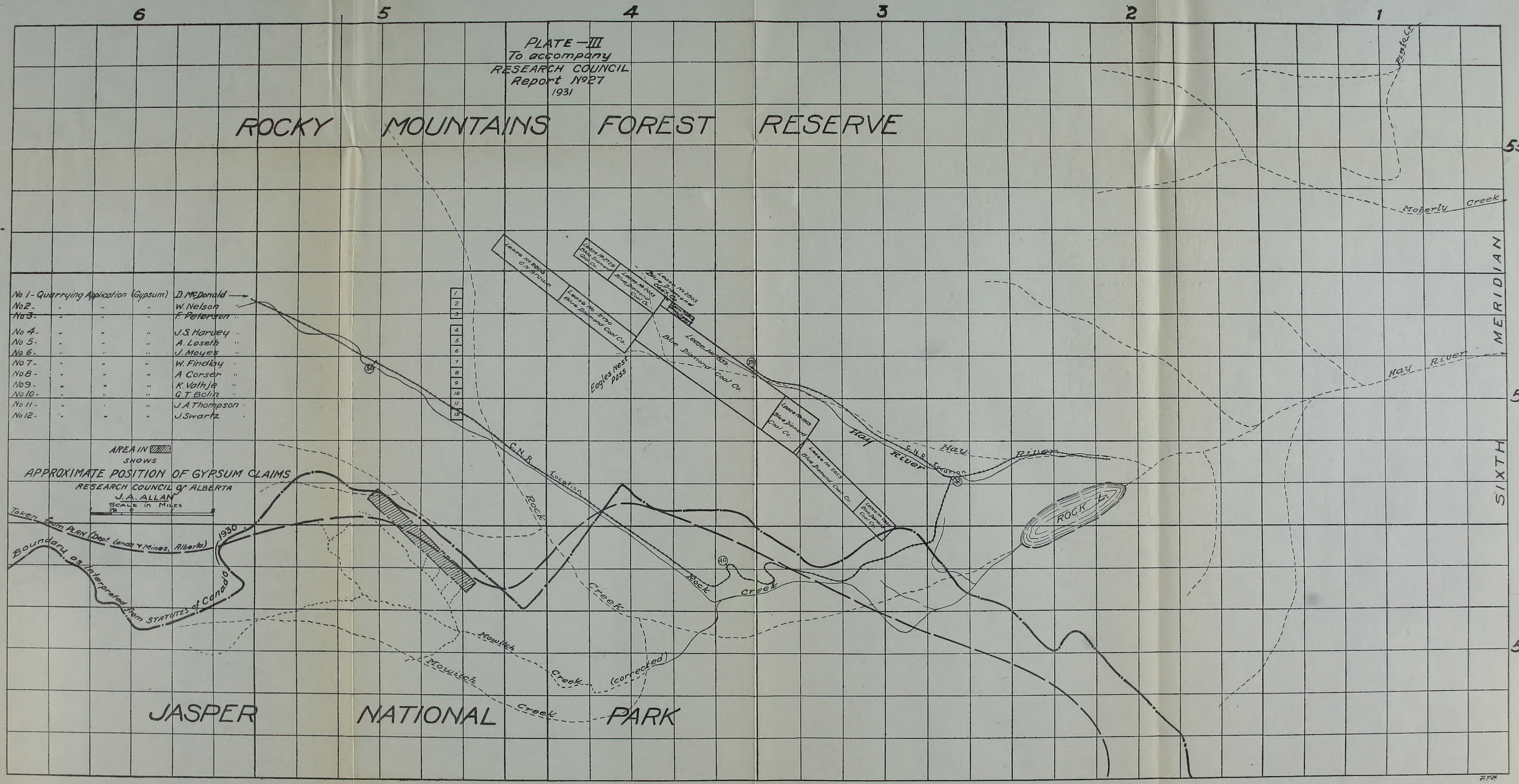
No. 19 (1928); GEOLOGY OF THE AREA BETWEEN NORTH SASKATCHEWAN AND McLEOD RIVERS, ALBERTA, by R. L. Rutherford; pp. 37 and 3-color map (Serial No. 13). Scale 1 inch to 3 miles. **Price 50 cents.**

No. 21 (1930); GEOLOGY AND WATER RESOURCES IN PARTS OF PEACE RIVER AND GRANDE PRAIRIE DISTRICTS, ALBERTA, by R. L. Rutherford; pp. 80 and 6-color map (Serial No. 14). Scale 1 inch to 4 miles. **Price $1.00.**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To accompany
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ROCKY MOUNTAINS FOREST RESERVE
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No 7 - " " " W. Findlay "
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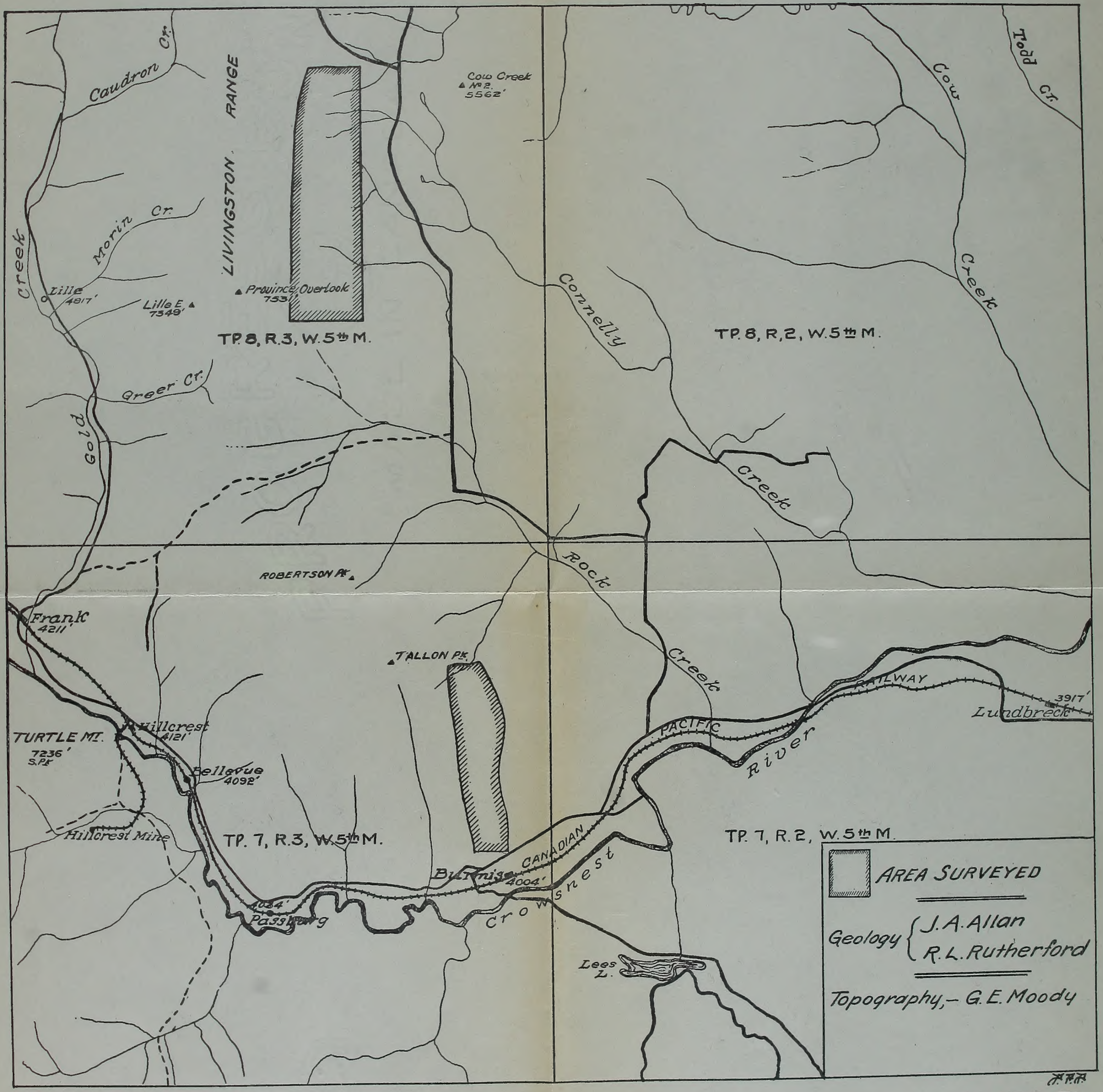
No 9 - " " " K. Vathje "
No 10 - " " " G.T. Bolin "
No 11 - " " " J.A. Thompson "
No 12 - " " " J. Swartz "
1
2
3
4
5
6
7
8
9
10
11
12
Lease No 2803 O.N. Brown
Lease No. 2790 Blue Diamond Coal Co.
Lease No 2728 Blue Diamond Coal Co.
Lease No 2033 Blue Diamond Coal Co.
Lease No 2805 Blue Diamond Coal Co.
Blue Diamond Coal Co.
Lease No 839.
Eagles Nest Pass
Lease No 1203 Blue Diamond Coal Co.
Lease No 2853 Blue Diamond Coal Co.
Lease No 2860 Blue Diamond Coal Co.
Hay River
C.N.R. Location
C.N.R. Location
Hay River
56
370
40
52
ROCK L.
AREA IN ▨ SHOWS
APPROXIMATE POSITION OF GYPSUM CLAIMS
RESEARCH COUNCIL OF ALBERTA
J.A. ALLAN
SCALE in MILES
½
0
1
2
Taken from PLAN (Dept Lands & Mines, Alberta)
1930
Boundary as interpreted from STATUTES of Canada
Rock Creek
Rock Creek
Mowitch Creek
Mowitch Creek (corrected)
JASPER NATIONAL PARK

Plate III.—Map showing position of gypsum claims as recorded in the Department of Lands and Mines, and their position as determined by our survey.



MAP SHOWING

POSITION OF IRON PROSPECT AREAS

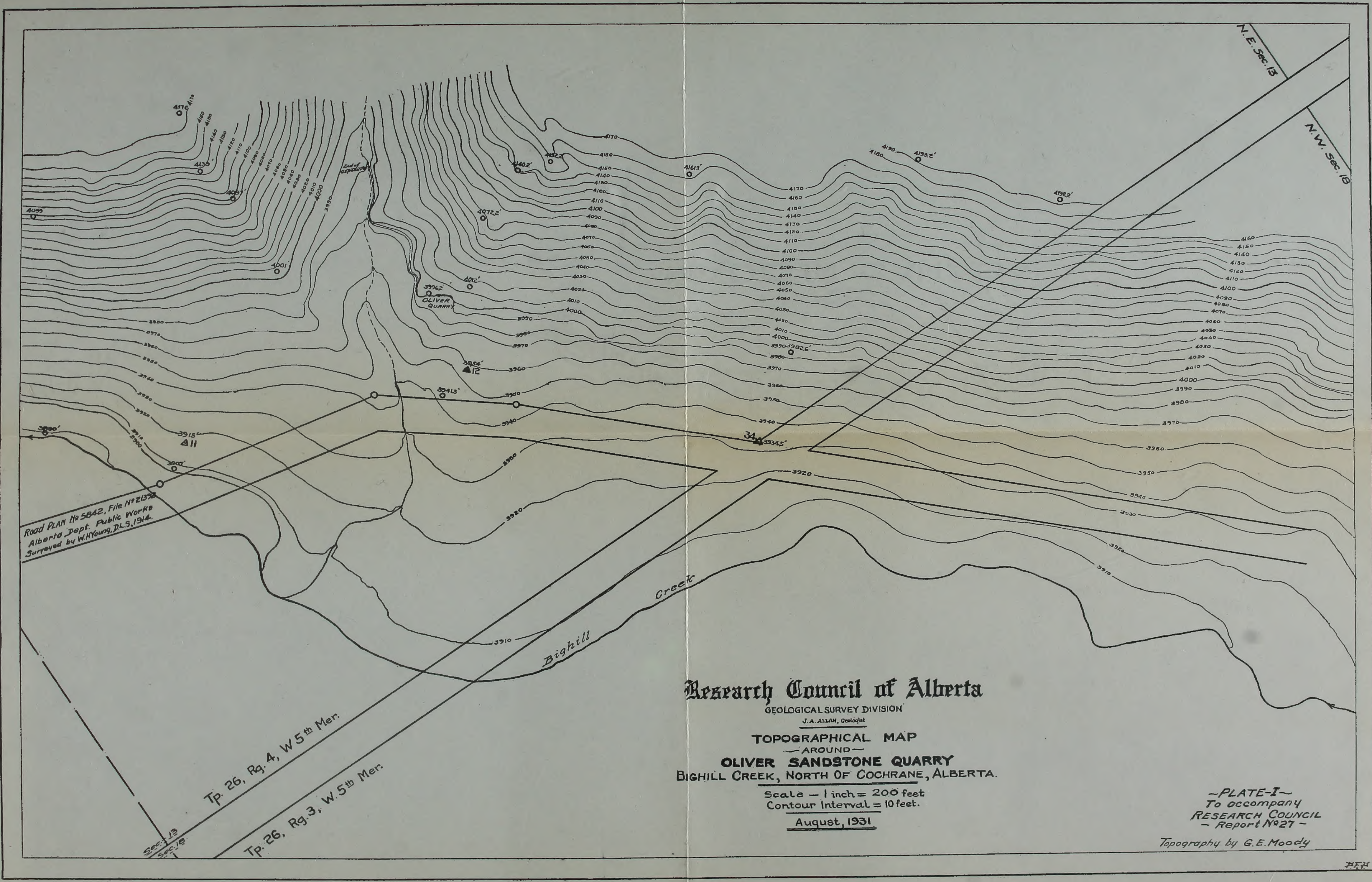
—SURVEYED BY—

RESEARCH COUNCIL OF ALBERTA

—1931—

SCALE - 1 inch = $\frac{3}{4}$ mile

PLATE-II
To accompany
RESEARCH COUNCIL
Report No 27



Research Council of Alberta
GEOLOGICAL SURVEY DIVISION
J. A. ALLAN, Geologist

TOPOGRAPHICAL MAP
—AROUND—
OLIVER SANDSTONE QUARRY
BIGHILL CREEK, NORTH OF COCHRANE, ALBERTA.

Scale — 1 inch = 200 feet
Contour Interval = 10 feet.

August, 1931

—PLATE-I—
To accompany
RESEARCH COUNCIL
— Report No 27 —

Topography by G. E. Moody